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THE EFFECTS OF WEIGHT AND LENGTH ON THE PORTABILITY OF ANTITANK SYSTEMS FOR THE INFANTRYMAN

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HUMAN ENGINEERING LABORATORY



ABERDEEN PROVING GROUND, MARYLAND

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THE EFFECTS OF WEIGHT AND LENGTH
ON THE PORTABILITY OF
ANTITANK SYSTEMS FOR THE INFANTRYMAN

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ABSTRACT

A field study was conducted to determine the effect of weight and length of an antitank system on the performance of an infantryman. A portability test course was designed and constructed. The ability of soldiers from the 82d Airborne Division to negotiate the course was measured and the soldiers' ratings of each of the systems they carried were obtained. Functional relationships between weight, length and performance were obtained with an indication of the effects of volume, i.e., multiple carry. The test soldiers were able to discriminate among the loads using the bipolar adjective rating technique, and for what appears to be a reluctance-to-carry factor, tended to rate the loads carried in a manner which parallels the performance findings. The infantryman's performance degrades and he is reluctant to carry 81mm antitank systems longer than 31 inches (at eight pounds) and heavier than eight pounds when added to his current fighting load.

PREFACE

The expertise provided by a number of people contributed to the successful completion of The Effects of Weight and Length² on the Portability of Antitank Systems for the Infantryman report. We would especially like to thank:

Captain Charles Matts, who while serving as Test Officer, provided the key to the success of the field study by acting as the driving force in keeping the test soldiers highly motivated to perform strenuous tasks for several weeks while maintaining a high degree of esprit de corps.

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THE EFFECTS OF WEIGHT AND LENGTH ON THE PORTABILITY OF ANTITANK SYSTEMS FOR THE INFANTRYMAN

INTRODUCTION

The effort described in this report was undertaken as a part of the U. S. Army Materiel Command's (AMC) SMAWT Program, an acronym for Short-Range Man-Portable Antitank Weapon Technology Program.

The objective of the program was to provide the U. S. Army Combat Developments Command a trade-off matrix between antitank weapon design parameters and performance. The Combat Developments Command could use the matrix in the definition of an antitank system to replace the M72 LAW.

The Human Engineering Laboratory was required to answer the question, "How much can an antitank system weigh and how long can it be?"

From the infantryman's point of view, the foot soldier is constantly trading off the weight and bulk of the equipment he carries with the requirements of his mission. With regard to antitank systems, he would on the one hand like a system that will give him more capability than the current M72 LAW. On the other hand, he is reluctant to pay the weight and bulk penalty associated with an improvement in capability. This report is an attempt to provide him with relationships between performance penalties and weight and length of the antitank systems.

To answer the questions of how much an antitank system can weigh and how long it can be, we must first consider some questions about the conditions under which it must be carried and used:

1. Who is going to carry it?
2. How is he going to carry it?
3. How many will he carry?
4. How far?
5. Over what type of terrain?
6. How long (often)?
7. How much else is he carrying?
8. In what type of climate?
9. What tasks must he accomplish while he is carrying it?
10. What tasks must he accomplish when he has finished carrying it?

Prior to the design of a test course to measure the tasks that an infantryman is required to perform, we met with the CDC Infantry Agency to solicit their thoughts on the above questions, to obtain scenarios (Appendix B) from which we could delineate the tasks required, and to construct a course which we felt would be as representative as possible of the various situations in which an infantryman might find himself.

We were, and are, only interested in the changes that weight and length produce in terms of changing the level of performance of infantry-relevant tasks; i.e., those required to perform the necessary functions to accomplish most missions. For example: his ability to aim a rifle, aim an antitank system, throw a grenade, negotiate obstacles, carry equipment, run, jump and climb, etc.

In addition, we visited the Weapons Department and the Airborne Department of the U. S. Army Infantry School at Fort Benning, GA, in order to survey their opinions regarding the same questions, and to determine limits associated with parachuting (Appendix C).

From AMC's point of view, the technology program was to look at both 66mm and 81mm systems in both rocket and recoilless configurations. Initially, potential configurations varied in length from 31 inches in the collapsed stage to as long as 43 inches. Thus, using the current LAW at 25 inches as a control, it could be seen that we wanted to vary length from at least 25 inches to 43 inches. We certainly wanted to investigate the range of values from LAW at approximately five pounds to a multiple carry situation, which we chose to be some multiple of the design goal of the program, namely, eight pounds. Therefore, we chose 24 pounds as the upper limit.

Additionally, there was a concern over the potential differences in volume given the same diameter round, that is, the additional volume associated with the plenum chamber of a recoilless system.

Therefore, there were differences in tube diameters, differences in volume given the same projectile diameter, differences in length due to the particular proposed configurations, the potential differences in weight, the differences due to different means of carry and the comparison with LAW. Although from an experimental point of view, it would have been most efficient to merely examine the effects of weight and length, there were many specific combinations of conditions that needed to be examined. Since not all conditions could be examined, we began to eliminate some parameters of interest. The first to go was differences in diameter. We presumed, based on the data presented by the U. S. Army Materiel Systems Analysis Agency, that sizable improvements over the LAW would best be obtained in jumping from 66mm to 81mm warhead diameter. So we chose to eliminate, except for the control system, the 66mm comparison.

Next, we ran a pilot study by having a few enlisted men and officers from the laboratory complete the obstacle course, which will be described later, and made the judgment that the course would not be sensitive enough to pick up differences in volume due to the plenum chamber; and, coincidentally, we found that there were tests made by a private contractor which demonstrated the lack of a need for a bulging plenum. Therefore, we eliminated the plenum chamber as a parameter.

Since we wanted to look at several lengths and at least a couple of multiple carry situations--and knowing full well it could not all be done parametrically in one experiment--we settled for testing 12 conditions.

We made one primary assumption. We assumed that the future antitank weapon would replace the M72 LAW and therefore would be issued to and carried by the rifleman.

METHOD

Based on a review of the scenarios provided by the CDC Infantry Agency, the Army Field Manual on Physical Readiness Training, the work accomplished by the U. S. Army General Equipment Test Activity to develop the combat effectiveness test facility, and a prior portability study (unpublished) accomplished by the Human Engineering Laboratory (HEL), a portability course was conceived to examine many of the tasks infantrymen would be required to perform and primarily, those tasks which would interact most with carrying an antitank weapon.

The portability course consisted of three portions:

A cross-country portion consisting of a trail 4,000 feet long, marked on both sides with white engineer tape. Along the trail, there were fallen trees, heavy brush, a two-log bridge, a two-rope bridge, thick woods and a stream to ford.

A road march portion of the course consisting of a marked walk on dirt and hardtop roads, 3700 feet long. It extended from the cross-country portion to the obstacle portion.

An obstacle portion consisting of 23 pairs of obstacles that had to be negotiated and several tasks that had to be performed.

Appendix A is a schematic description of the total portability course, each obstacle and each performance task on the obstacle course.

The purpose of the cross-country course was twofold. First, it was intended that the cross-country portion would fatigue an individual and second, we felt that by having him carry the load at his own pace through the variety of circumstances that were provided on the cross-country portion, it would give him a basis from which he would be able to rate the various loads that were carried. The road march portion of the portability course was also intended to give him the experience of walking with the systems for a reasonable period of time.

The obstacle portion of the course was designed to subject each man to those kinds of circumstances that would be encountered in a variety of fighting situations and measure his ability to perform infantry-relevant tasks; such as running, jumping, swinging, balancing, vaulting and crawling. We also hoped to uncover incompatibilities that might exist between the equipment and tasks. As can be seen from Appendix A, we included city fighting situations wherever possible; i.e., doorways, stairways, down-and-out, alley, sewer pipe, etc. Several psychomotor tasks; such as aiming, dry firing and reloading the M16, throwing a hand grenade through a window, aiming an M14 rifle and firing blanks at a man-silhouette target 40 meters away and tracking a 5-mile per hour target were included. In addition, as a measure of residual stamina after completing the obstacle course, a digging task was included whereby the men were required to dig 1400 pounds of sand with their entrenching tool as quickly as possible and not to exceed 15 minutes.

Some of the obstacles on the course were designed to provide the realism encountered in city fighting and to accommodate the SMAWT ruggedness sub-study which was run concurrently. The purpose of the sub-study was to determine the ruggedness of throw-away fiberglass tubes representing the most current design for both the recoilless and rocket systems.

By reviewing the obstacles in Appendix A, it can be seen that the first and last runs in the vault obstacles, both high and low, were made of steel pipe; in the down-and-out the railings were steel pipe on one side and angle iron covering wood on the other, whereas the top of the wall within the down-and-out was a slab of concrete. Slabs of concrete were also placed at the leading edge of the alley and the doorways at the top of the stairs. In addition, the edge of the top of the 5-foot wall was covered with angle iron. The course was "hardened" in this manner so that the kind of impulsive striking and rapping of antitank material, while fighting in cities and from around vehicles, would be simulated to some extent (although admittedly arbitrary).

Instrumentation

From the top of an observation tower, two cameramen photographed each of the two men proceeding through the obstacle course. For the first quarter of the experiment, the 16mm cameras were run at 24 frames per second. Thereafter, in order to conserve on film but at the same time obtain a record of any incompatibilities that occurred as a result of a load-obstacle interaction, the cameras were run eight frames per second.

A test officer and two soldiers were equipped with stopwatches and recorded times to complete the total course, the high crawl and the low crawl, to the nearest one-hundredth of a minute for each subject.

Firing task. An M14 rifle was equipped with a specially designed gun camera to measure aiming error. A picture was taken each time the subject fired a blank round at a man-silhouette target exposed for two seconds at 40 meters.

Aiming and tracking task. An 81mm aluminum tube equipped with a three-power telescope with a crosshair in the reticle was used as an aiming device. It weighed approximately 8 pounds. A 16mm moving-picture camera was mounted within the tube. The camera speed was 24 frames per second. The subject was required to track a jeep moving at 5 miles per hour from left to right. The jeep was equipped with a rectangular target with a black-on-white cross which acted as an aiming point. It was located 168 meters from the firing position.

Digging tasks. The digging apparatus¹ consisted of a sandpit from which 1400 pounds of sand was shoveled into a large hopper. This could be accomplished while kneeling. The hopper was suspended from an overhead supporting member and, with a chain-pulley system, was capable of being moved so that the sand could be replaced in the pit within a few minutes after being filled to capacity. An observer recorded the time it took to fill the hopper to 1400 pounds of sand which was measured by a scale connecting the chain holding the hopper to the overhead support member.

An observer with a stopwatch recorded the time when each pair of subjects began and completed the cross-country portion of the course. A referee randomly observed the pairs of subjects walking through the cross-country portion of the course to insure their passage between the engineering-tape markers.

¹Digging apparatus was identical to that designed and fabricated by the U. S. Army General Equipment Test Activity, Fort Lee, VA, under TECOM Project No. 8-CO-267-000-001.

A Yellow Spring Instrument Company telethermometer (a Wet Bulb Globe Thermometer) (WBGT) was available on site. A WBGT reading was taken every half-hour in order to comply with TB MED. 175, DA Circular 40-86, and FM 21-10, so that no subject was required to participate in the field study when the WBGT was in excess of 88 degrees.

Tubes

Table 1 shows the various loads carried. Eighty-one millimeter tubes were constructed of steel. End caps were welded in place. The 8-pound systems were constructed so their center of gravity and moment of inertia were as close to the MICOM design as possible. The 8-pound tube relationships were used to generalize to the 16- and 24-pound systems. Each tube had a one-inch wide canvas carrying strap, a simulated trigger mechanism and to begin with, a sight bracket designed by Frankford Arsenal to accommodate an Advanced LAW three-power stadiametric optical sight. However, the sight bracket was removed when a pilot study showed it to be a hazard with the heavier systems.

TABLE 1

Loads Carried

Code	Length (Inches)	Weight (Lbs.)
C	25	5 (LAW)
L	25	8
K	25	16
J	25	24
I	31	8
H	37	8
G	37	16
F	37	24
E	43	8
D	43	24
A	25	24 (3 ea. 8 lb.) Multiple Carry
B	31	24 (3 ea. 8 lb.) Multiple Carry

Loads Carried

It can be seen from Table 1 that the M72 LAW acted as the control and that the length of the mockup weapons was varied in 6-inch increments from 25 inches to 43 inches while weight was kept constant at 8 pounds. For selected lengths; i.e., 25 inches and 37 inches, weight was varied from 8 pounds to 24 pounds in 8-pound increments. For two additional selected lengths, 25 inches and 31 inches, volume was varied by strapping together three 8-pound 25-inch tubes and three 8-pound 31-inch tubes which permitted the tubes to be carried across the back parallel to the ground.

Subjects

Twenty-eight airborne infantrymen from the 82d Airborne Division acted as test soldiers. All had enlisted voluntarily and many had volunteered specifically for the 82d Airborne Division. All had completed Advanced Infantry Training and most of the men had recently completed their airborne training. The senior four of the 28 men were Specialists 4. They assisted in collecting obstacle course time data.

Procedure

The portability course was located at Aberdeen Proving Ground, MD. The study began in late August 1972 and ended in early October 1972.

Before the study began, the test subjects were briefed regarding the purpose of the field study and the importance of the findings. They were briefed regarding the manner in which they were to accomplish the total course and they walked through all three portions of the portability course (Appendix A). Then they were required to complete the course only in their fatigue uniform with boots. This trial was called DAY ZERO - NO LBE.

The next day they were required to run the course with their Load Bearing Equipment (LBE) and M16. From this point on in the report, LBE will signify the normal fighting load. The fighting load (approximately 37 pounds) is shown in Table 2. This was done to familiarize them with the course while loaded with their fighting load.

The next day the men ran the course for record with LBE. This was called Day R. Based on their time to complete the obstacle course only, they were divided into two equally-matched teams. This was done so that each man would be competing with a man equal to his ability. Each obstacle was duplicated on the course so that two men could run simultaneously. A point system was used so that 10 points were given for the completion of each obstacle and 10 bonus points were received if an individual completed the obstacle course in the mean time that it took both teams to complete the course that day. Therefore, we attempted to motivate the men by providing individual competition; i.e., one man running against another, team competition, performance feedback by providing the scores at the beginning of the next day and with reward by promising the winning team a free beer-bust at the end of the study.

TABLE 2
Fighting Load
(LBE)

	Approximate Weight (Lbs.)
I Clothing:	
(1) Helmet w/liner	3.13
(2) Trousers and Jacket (jungle) (med)	2.63
(3) Underwear (summer) and Socks (2 sets)	1.26
(4) Boots (leather DMS)	4.00
(5) Poncho	2.94
Total	13.96
II Equipment:	
(1) Rifle w/sling (M-16)	7.06
(2) 100 Round ammo w/5 (20 rd mag)	3.44
(3) Ammunition pouches (2) (20 rd mag)	1.38
(4) Canteen (filled) w/carrier	2.81
(5) Belt, M-14 w/first aid pouch and packet, and suspenders (all cotton)	2.50
(6) Entrenching tool w/carrier (folding)	3.75
Total	20.94
III Rations	
(1) Meal (1) (MCI)	1.80
Total Weight	36.70

Each man was required to carry each load (conditions A through L) twice through the course; once in the morning and once in the afternoon. Each man was required to complete the course twice a day, every other day. Counterbalancing the effects of learning and fatigue was achieved by ordering the loads and assigning subjects as shown in Table 3.

In order to have some indication as to the effect of learning the course, the men ran with the LBE gear for record on three different days: at the beginning, Day R; one-third of the way through, Day R2; and two-thirds of the way through the experiment, Day R3.

Each day's scenario was as follows: Twelve men, six from each team, were assigned the load they were to carry that day. Before proceeding to the cross-country portion of the course with LBE and load for that day, each man was required to track a moving jeep target with the 8-pound tube simulating a potential antitank system. Aiming data were obtained from a 16mm gun camera securely mounted in the tube. He was required to track the vehicle from a kneeling position, going from left to right, for a period of 3 seconds. Then he was required to take the prone position and track the target on its return trip from right to left for 3 seconds.

Next, he was required to fire eight blank rounds from an M14 rifle at a pop-up man-silhouette target exposed for two seconds, 40 meters away.

The men were then transported via bus to the beginning of the cross-country portion of the course.

An NCOIC started each pair of men 10 minutes apart on the cross-country portion and recorded the time they finished. Then the men walked (road march portion) on a marked route over dirt and hard-surface road from the portability portion to the obstacle portion. At the obstacle portion, the captain in charge started the men on the obstacle course. By photographing each man negotiating the obstacles, the time to complete any given obstacle, difficulties associated with any obstacle and incompatibilities between the loads and the tasks were measured. Since there was no real way to know in advance what measure or sets of measures would discriminate among loads, it was felt that the moving picture technique was probably the only way to encompass the total experience. The officer and two of the specialists recorded the time to complete the total course, the time to complete the high crawl and the low crawl and also noted any obstacles that were not completed.

On the morning of the first day, half of the men carried the load bandoleer style and the other half in sling arms fashion, and vice versa in the afternoon. At the end of the day, a questionnaire was administered to see if there was any preference. The preference was bandoleer style as shown in Appendix A. Therefore, the remainder of the study was conducted with each man carrying each tube, except for the triple loads, in bandoleer fashion. A few points worth mentioning and also shown in the fold-out in Appendix A are:

1. The crawl courses were cut down in length because it was found in the pilot study that the course could not be completed if the initial total distances were attempted.

2. After the high crawl, the men were required to "hit the prone" position, take up a firing position, dry fire their M16 five times, take out the old magazine, take out a magazine from the magazine pouch, put it into the weapon and put the old magazine back into the pouch.

TABLE 3

Load

Subject	Day											
	1	2	3	4	5	6	7	8	9	10	11	12
1 13	A	B	C	D	E	F	G	H	I	J	K	L
2 14	B	D	F	H	J	L	A	C	E	G	I	K
3 15	C	F	I	L	B	E	H	K	A	D	G	J
4 16	D	H	L	C	G	K	B	F	J	A	E	I
5 17	E	J	B	G	L	D	I	A	F	K	C	H
6 18	F	L	E	K	D	J	C	I	B	H	A	G
7 19	G	A	H	B	I	C	J	D	K	E	L	F
8 20	H	C	K	F	A	I	D	L	G	B	J	E
9 21	I	E	A	J	F	B	K	G	C	L	H	D
10 22	J	G	D	A	K	H	E	B	L	I	F	C
11 23	K	I	G	E	C	A	L	J	H	F	D	B
12 24	L	K	J	I	H	G	F	E	D	C	B	A

C	25"	5 ^{lb}	LAW	B	31	8	3 ea
L	25	8		H	37	8	
K	25	16		G	37	16	
J	25	24		F	37	24	
A	25	8	B 3 ea.	E	43	8	
I	31	8		D	43	24	

3. The men were required to "hit the prone" position in the alleyway after throwing the grenade through the simulated window.

4. If a man was unable to complete an obstacle; i.e., scale the five-foot wall when carrying a 24-pound system, he was permitted three attempts and if he failed was permitted to go around the obstacle.

After completing the final obstacle on the course proper; i.e., jumping into the two-man foxhole, the men were once again required to fire the M14 and track the moving target with the simulated antitank system. Then they proceeded to the digging area where they removed their LBE and load and only in fatigues from a kneeling level, were required to dig 1400 pounds of sand with their entrenching tool as quickly as possible and not to exceed 15 minutes.

Upon completing the digging of 1400 pounds of sand, which represents approximately half the weight of a two-man foxhole, they were required to fill out a questionnaire (Appendix D), which surveyed their experiences regarding the load they carried and permitted a comparison among the conditions investigated. Some questions in the questionnaire used bipolar adjectives and required the soldiers to rate the parameters of interest on a five-point scale.

It should be noted that the questionnaire was completed once a day after digging in the afternoon.

At the completion of the study, the men were required to rank order the 12 loads from the easiest to the hardest to carry by actually positioning them on the ground. They were then required to indicate which loads they "absolutely would not carry into combat given that all systems were equally effective against tanks."

RESULTS

Negotiating

The data have been processed to the following extent. We have the total time it took an individual to complete the obstacle course, the time it took him to crawl through the high crawl and through the low crawl, and the number of occasions that he was unable to complete an obstacle; for example, to get over the 5-foot wall. This does not mean having difficulty with an obstacle; for example, he may have tried twice and managed to get over on the third try. We have the time it took to dig and the tabulated responses to the questionnaires. The aiming data on the antitank system are processed but only partial data on aiming the M14 rifle are available.

Table 4 presents the mean and standard deviations of the times to complete the high crawl, the low crawl, the total obstacle course, and the digging for each of the 12 conditions. The pre-test No LBE condition and the three LBE conditions are also shown. In addition, the frequency of obstacles not completed is given. Time is given in minutes and hundredths of minutes.

TABLE 4
Obstacle Course Scores

Condition	Code	Time (Min.)		Obstacle Course	Dig	Frequency of Obstacles Missed
		High Crawl	Low Crawl			
LAW/5 25	C	\bar{x} σ .25 .06	.43 .17	4.91 .62	5.80 1.15	0
25/8	L	\bar{x} σ .26 .07	.47 .15	5.08 .77	5.51 1.17	0
31/8	I	\bar{x} σ .28 .08	.55 .18	5.25 .95	5.82 1.82	2
43/8	E	\bar{x} σ .29 .06	.51 .13	5.37 .84	5.41 1.16	1
37/8	H	\bar{x} σ .28 .09	.61 .22	5.60 1.16	6.07 2.28	2
25/16	K	\bar{x} σ .32 .09	.56 .24	5.69 1.17	4.95 1.75	8
37/16	G	\bar{x} σ .32 .08	.61 .22	5.92 1.10	5.49 1.79	4
37/24	F	\bar{x} σ .34 .08	.73 .23	6.32 1.05	5.69 1.48	1
25/24	J	\bar{x} σ .35 .12	.65 .26	6.41 1.33	5.77 2.10	5
Three/8 25	A	\bar{x} σ .35 .09	.84 .27	6.62 1.03	6.14 1.98	13
43/24	D	\bar{x} σ .37 .11	.75 .33	6.87 1.11	6.15 1.40	16
Three/8 31	B	\bar{x} σ .34 .09	.95 .37	6.97 .99	5.76 1.80	11
No LBE	Day: Zero	\bar{x} σ .15 .04	.27 .06	4.16 .56		0
LBE	Day: R	\bar{x} σ .22 .05	.34 .08	5.17 .63	6.59 .87	0
LBE	Day: R2	\bar{x} σ .20 .07	.30 .13	4.39 .61	5.81 .59	2
LBE	Day: R3	\bar{x} σ .26 .06	.39 .10	4.55 .61	5.81 2.14	0

A three-way analysis of variance was performed on the time to complete the obstacle course data for the 12 conditions of the experiment (Table 5). Differences between people, between morning and afternoon and between loads were all significant at the .05 level of confidence. Since there were no interactions between people and time of day, or loads and time of day, the morning and afternoon data (considered as infantryman's day) were combined to look at the differences between treatment (load) means.

A Tukey-A test was conducted (after a two-way ANOVA presented in Table 5) on all ordered pairs of the load means and Table 6 presents the means and the darkened line represents the differences between any pair of means significant at the .05 level of confidence.

Since the Tukey-A test is a very stringent, conservative test and dependent on the range of values tested, and since the primary interest of the SMAWT program is at the lower end of weight and length, a more sensitive test (Dunnett) was applied to compare the LAW with the four 8-pound loads.

It can be seen from Table 6, and is shown in detail in Tables 1E and 2E (Appendix E), that using the LAW as a control and comparing the four 8-pound loads with it, the E (25-inch 8-pound) and I (31-inch 8-pound) loads did not differ significantly from the LAW but the E (43-inch 8-pound) and H (37-inch 8-pound) did at the .05 level of confidence.

Since the absolute time to complete the course does not provide easy conceptualization of the relative change between conditions, and to permit reasonable generalizations from the conditions, the percent change in course time was calculated as the most meaningful dependent measure. In addition, it is believed that the strength of this study lies in the establishment of functional relationships between weight, length and performance rather than the specific differences or lack thereof between any two means.

Figure 1 and Table 7 present the mean percent change in course time versus the total weight in pounds that the men carried for the 12 conditions of the experiment with the LBE mean set to zero. The No LBE condition is also shown. The LBE data point is the mean of three trials. The No LBE data point² mean was adjusted by taking the percent change difference between the first occasion that the LBE condition was run and the mean of the next two occasions, and weighting it as though it were also run three times. No other data points are adjusted. None of the 12 conditions of the test is adjusted.

On those few occasions where the men did not run a condition because of injury or sick call, the means represent the means of those that did run.

As can be seen, the means are very well ordered as a function of weight and length and multiply carry (volume) for all conditions except two; the 37-inch 8-pound system data point and the 37-inch 24-pound system data point.

After viewing the film, reviewing the raw data and examining the other 10 well-ordered means, we concluded that these two anomalous data points are "experimental noise."

²The No LBE data point throughout this report will be considered no weight, even though the soldiers wore their boots and fatigues for a total of 7 pounds, because the baseline for a no-load condition was obtained with 7 pounds of clothing. Thus the LBE data point on all curves represents a 30-pound load. If the reader should ever have need of scaling changes in behavior, he should be aware that this seven-pound difference change is a constant and held so throughout the report.

TABLE 5
Three-Way Analysis of Variance

Source of Variation	SS	df	MS	F
Subjects	227.80	23	9.904	23.469*
Load	277.29	11	25.208	59.734*
Time of Day	3.01	1	3.010	7.132*
Subject x Load Interaction	244.38	253	.965	2.286
Subject x Time of Day Interaction	9.41	23	.409	.969
Load x Time of Day Interaction	6.13	11	.557	1.320
Residual (SLT interaction)	106.91	253	.422	
Total	874.93	575		

*Significant @ alpha = .05 level

ANOVA

Source of Variation	SS	df	MS	F
Between subjects	461.98	23	20.086	
Within subjects	1037.15	264	3.928	
Loads	555.34	11	50.485	13.63*
Residual	943.79	253	3.73	
Total	1499.13	287		

*Significant @ alpha = .05 level

TABLE 6

Tukey^a Tests on all Ordered Pairs of Load Means

Order Load	1 C	2 L	3 I	4 *	5 E	6 H	7 K	8 G	9 F	10 J	11 A	12 B
\bar{M} Total Times	9.82	10.26	10.49	10.73	11.26	11.37	11.83	12.68	12.84	13.36	13.79	14.10
C		.43	.66	.90	1.44	1.54	2.01	2.85	3.01	3.53	3.97	4.27
L			.23	.47	1.00	1.10	1.57	2.41	2.58	3.10	3.53	3.84
I				.23	.77	.87	1.34	2.18	2.34	2.86	3.30	3.60
E					.53	.63	1.10	1.94	2.11	2.63	3.06	3.37
H						.10	.57	1.41	1.57	2.09	2.52	2.83
K							.46	1.31	1.47	1.99	2.42	2.73
G								.84	1.00	1.52	1.95	2.26
F									.16	.68	1.11	1.42
J										.52	.95	1.25
A											.43	.73
D												.30

$"T" = \frac{q_{.95}(12, 253) \sqrt{24(3.73)}}{24} = 1.82$
 Where:
 $"T" = \text{Tukey's number}$
 $n = 24$
 $q_{.95}(12, \infty) = 4.62$
 $MS_{\text{error}} = 3.73$

Differences in \bar{M} Times greater than "T" are significant at .05 level.
 Using Dunnnett Method E & H are significantly different than C whereas L & I are not at .05 level

^aWiner, B. J. Statistical principles in experimental design. New York: McGraw-Hill (Series in Psychology), 1962.

*Significant at .05 level using Dunnnett Method.

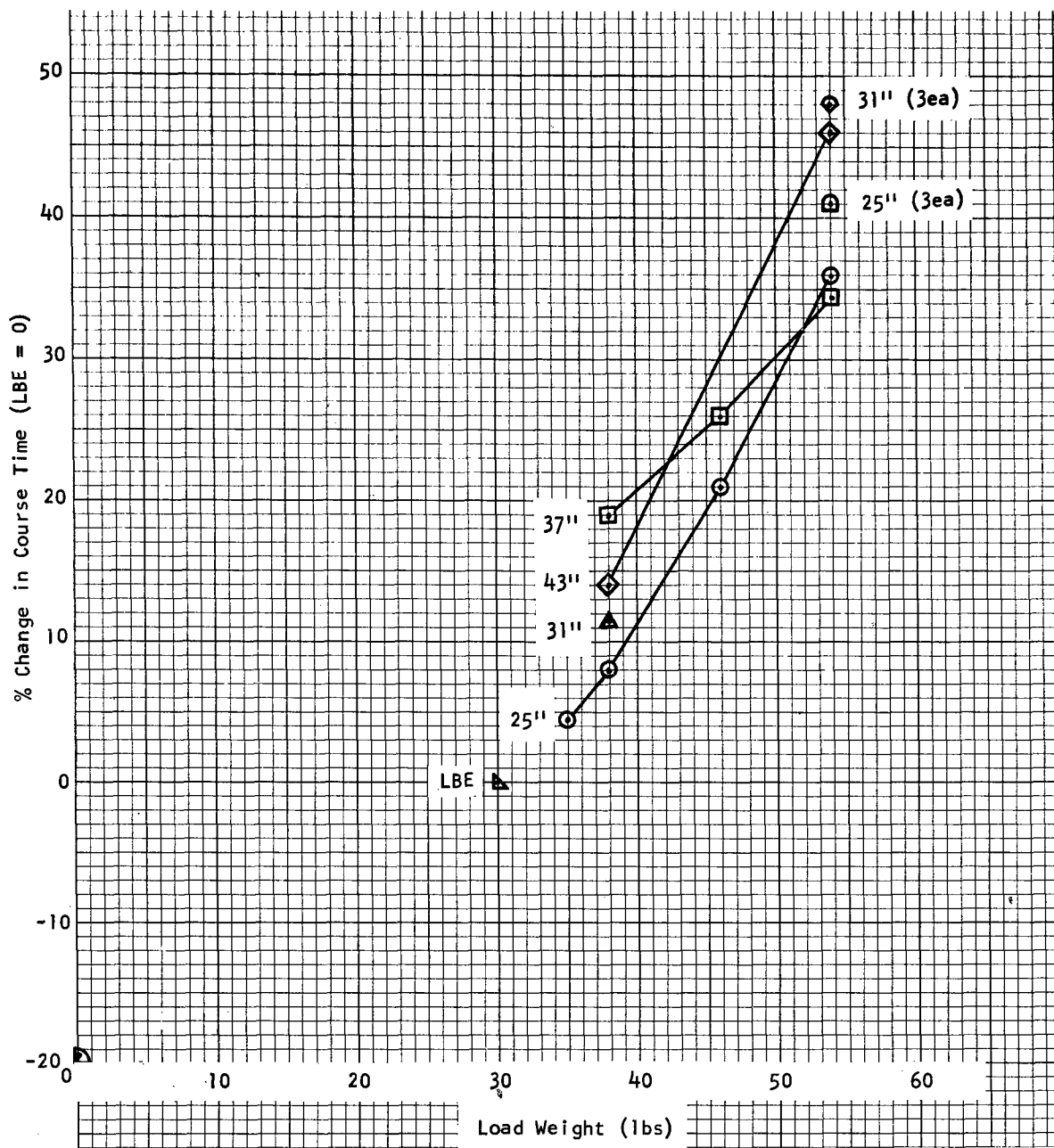


Fig. 1. Percent change in course time (LBE = 0) versus load weight (lbs.).

TABLE 7
Percent Change in Course Time

Weapon	% Change in Course Time LBE = 0
C(LAW) 5 lb	4.4
L 25" 8 lb	8.0
K 25" 16 lb	21.0
J 25" 24 lb	36.3
I 31" 8 lb	11.7
H 37" 8 lb	19.1
G 37" 16 lb	25.9
F 37" 24 lb	34.4
E 43" 8 lb	14.2
D 43" 24 lb	46.1
A 25" 8 lb 3 ea.	40.8
B 25" 8 lb 3 ea.	48.2
No LBE	-19.6
LBE	0

We presumed that the two 37-inch data points should lie between the 31-inch and 43-inch data points for the same weight.

It would have been nice to have run a regression analysis to determine the contribution to the total variance of weight and length but time did not permit it. On the other hand, because of the two anomalous data points, it may well be that when it is conducted it may present an estimate that is not as practical as the following procedure which was used.

For a single tube carry, it was assumed that the maximum increase in percent change in course time would occur with the 43-inch system, and the least change would be expected with the 25-inch system. Therefore, it was assumed that the other lengths for the same weight would fall between the 25-inch and the 43-inch system data points. The 31-inch 8-pound data point and the 37-inch 16-pound data point met this assumption. It looked as though a two percent difference in percent change in course time could be expected for every 6 inches of weapon length at 8 pounds, approximately a 2-1/2 percent change at 16 pounds and approximately a three percent change at 24 pounds. Using these data points and setting the LBE condition equal to zero, curves were fit to the data points using a least squares method, and are shown in Figure 2. The equations of the lines plotted and the values used are presented in Appendix F.

It is believed that the curves presented in Figure 2 are the best available estimates of the trade-offs between length and weight on the performance change of an infantryman.

Figure 3 presents the frequency of obstacles missed versus the type of system carried. No statistic was applied to these data. There was a tendency for some of the men not to complete some of the obstacles when they were loaded with the long 24-pound system or when they were carrying the 24-pound multiple-carry system.

As was shown previously, people differ in terms of their capability of carrying loads. It is well known to the infantryman that it is not uncommon to give heavier loads to the stronger people. Another way of looking at the data that might well be useful to the infantryman is as follows.

We assumed that the infantry rifle squad would proceed at the rate of the slowest man. Therefore, we took the mean of the three scores the slowest man obtained when he ran the LBE conditions. Setting that equal to zero, we then determined the percentage of men (scores) that would not be able to keep up with the slowest man at the fighting load as a function of adding the 12 loads of the test. Therefore, looking at Figure 4 we can say that if we added a LAW to an infantryman only 12 percent of them would not be able to keep up with the slowest man, or conversely, 88 percent of the infantry squad could be equipped with the LAW. Using a chi square statistic, it was found that all load combinations beyond 8 pounds and 31 inches (at 8 pounds) were significantly different than the slowest man with LBE at $p < .05$ level (Table 1G, Appendix G). At the other end of the curve, it can be seen that almost all men carrying three 8-pound 31-inch systems would not be able to keep up with the slowest man in the infantry squad.

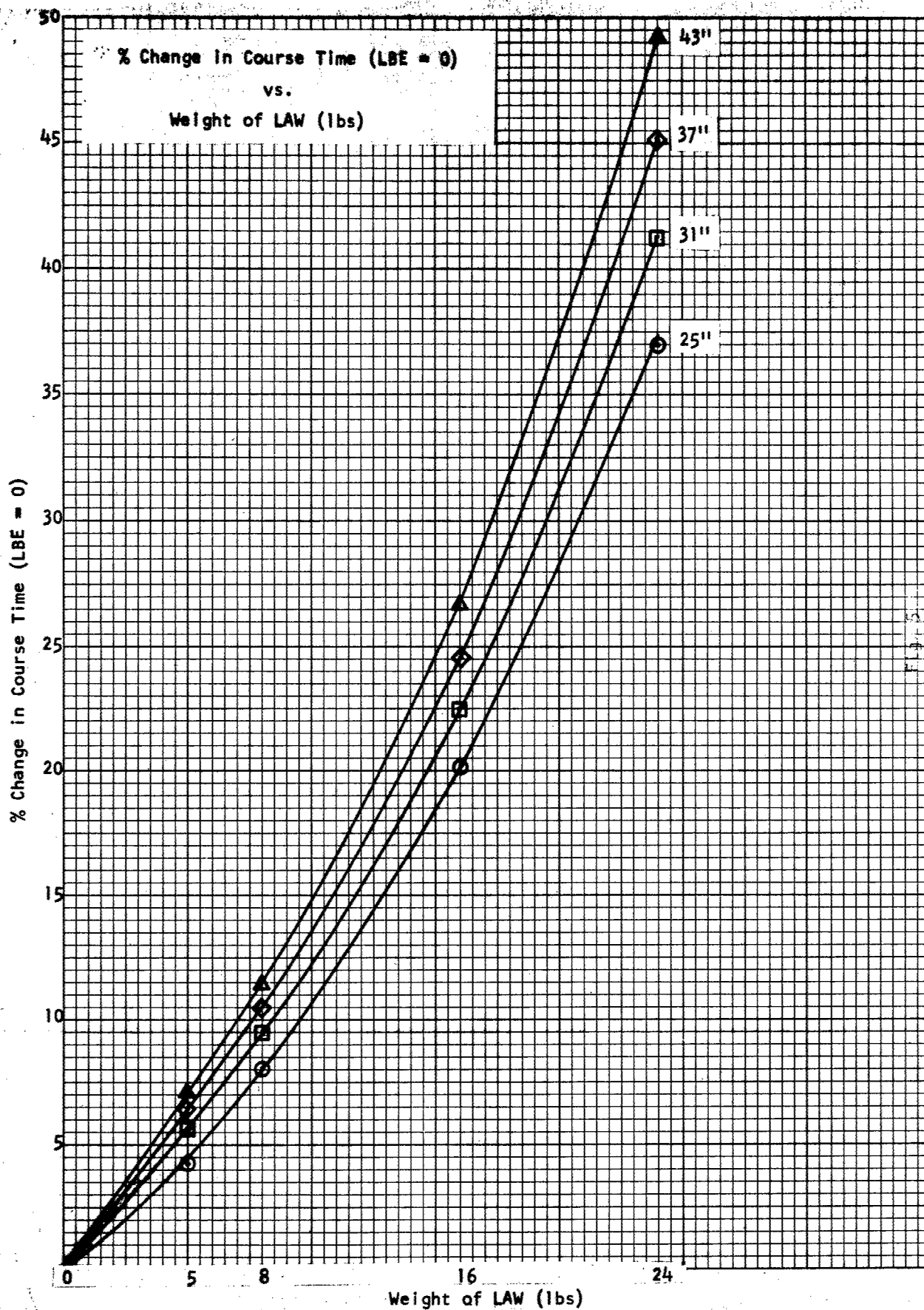


Fig. 2. Percent change in course time (LBE = 0) versus weight of LAW.

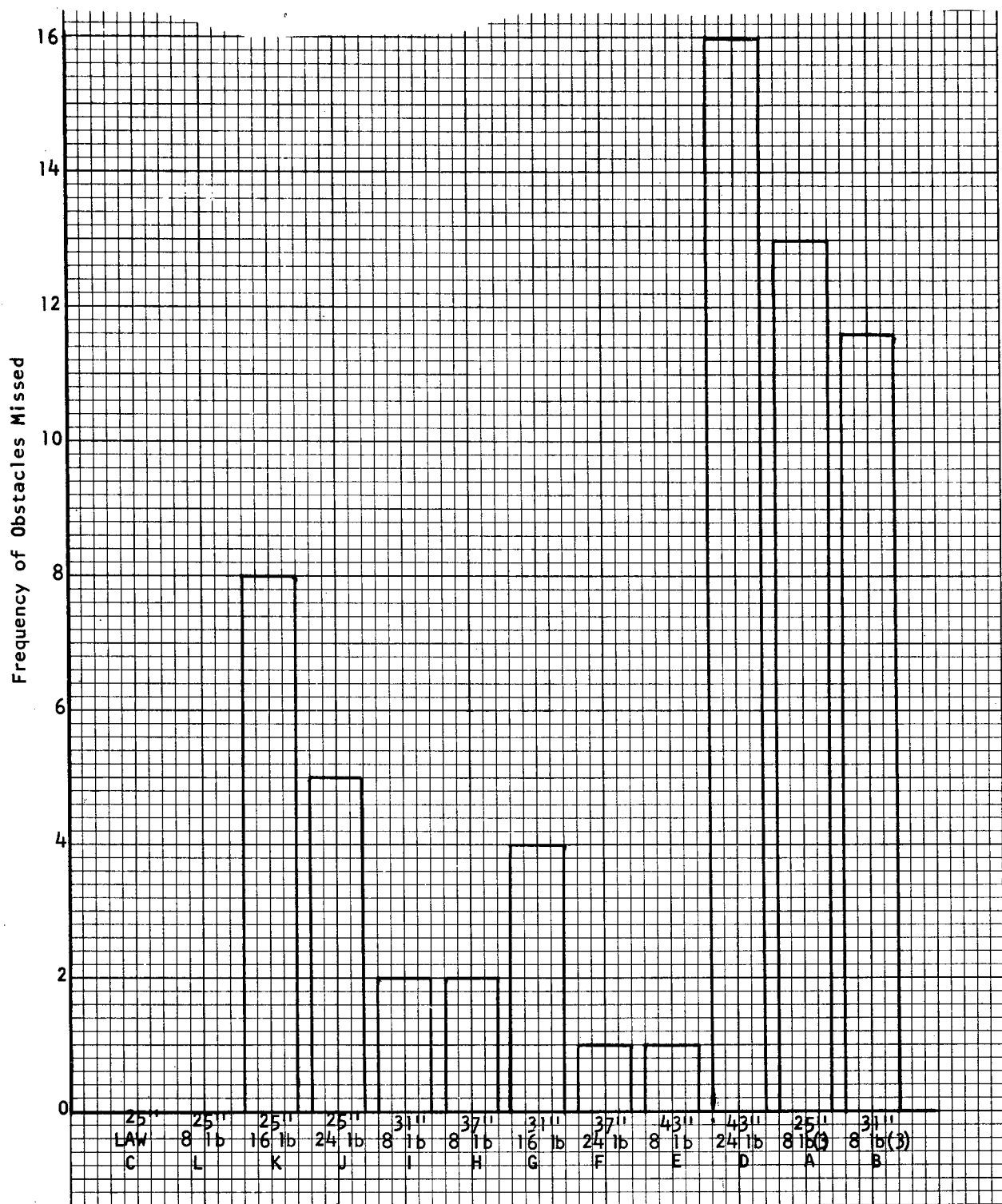


Fig. 3. Frequency of obstacles missed versus type of LAW carried.

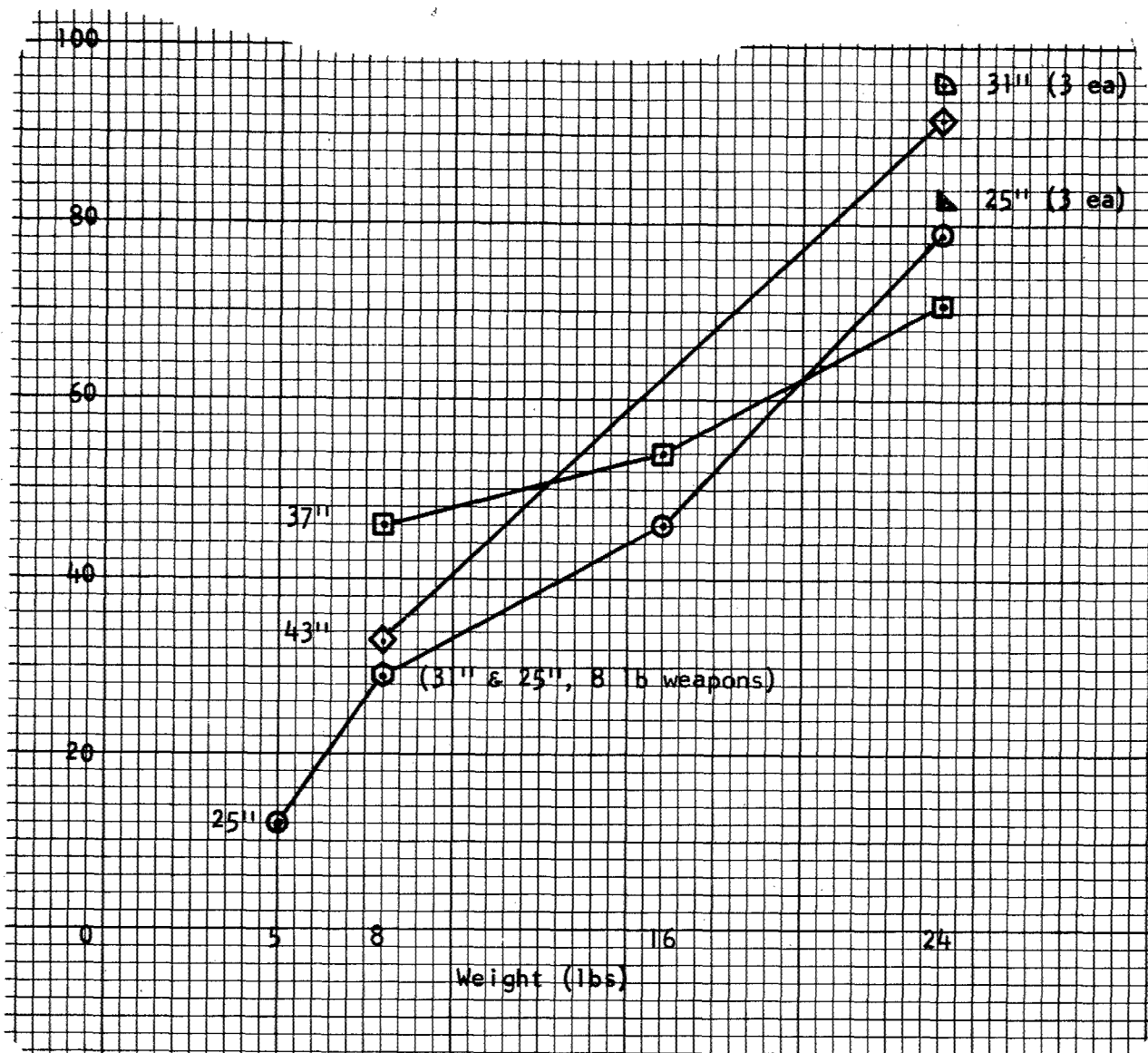


Fig. 4. Percentage of men not able to keep up with the slowest man at fighting load — not carrying antitank weapon.

Using the 25-inch and 43-inch length data points as the lower and upper limits,³ straight lines were fitted to the 43-inch and 25-inch data points using a least squares method and are shown in Figure 5. These are the best estimates of the trade-off between adding weight and length and population available to keep up with the infantry squad.

As a product of the SMAWT program, it was felt that the infantry might well be interested in only the effect of adding weight to an infantryman. A weight curve was generated using the data points for the No LBE, the LBE condition and the 25-inch systems as the best estimate of the relative change of adding weight to an infantryman. It was assumed that the 25-inch data points represented the least volume and therefore would be most representative of weight alone. The LBE point was set to zero and No LBE to a zero weight, i.e., the 7 pounds of fatigues and boots were not considered weight since they would be needed to run the course. Figure 6 shows the data points and the equation of the line generated using a least squares method.

Tracking

X and y coordinates were measured with a film reader beginning at 1/2-second after trigger pull every quarter-second for one second going from left to right and the same was repeated going from right to left. The radial standard deviations for each individual was computed and is shown in Tables 1H through 15H in Appendix H. Subject No. 18 obviously did not understand the instructions, since his behavior was more than three standard deviations from the group mean and therefore was not considered. There were a number of outlier data points which are asterisked in Appendix H. Since they were more than two standard deviations from the mean of the group they were not considered. There wasn't time to apply a rigorous procedure⁴. Table 8 shows the mean radial standard deviations by condition and the standard deviations about the mean of the before and after performance. There do not appear to be any trends that show that different loads affected tracking behavior. However, performance degrades approximately 10 percent after having completed the course ($t = 3.09$, significant at the .05 level).

Aiming

Unfortunately, most of the M14 data were lost. Ironically, all three of the cameras mounted to three different weapons, designed specifically for those weapons, malfunctioned in such a manner as to go undetected through the experiment. Thus there was no way to examine aiming behavior with the M14 as a function of the treatment conditions. Using the data that was randomly good (Table 1I, Appendix I), a comparison between before and after running the course was the only marginal comparison salvageable. The mean radial standard deviations available before and after, along with the associated sigmas, are presented in Table 9. The tendency is for aiming behavior to degrade after running the course.

³ Again, two of the 37-inch data points were assumed to be anomalous.

⁴ Grubbs, F. E. Precision of measurement, accuracy, and procedures for detecting outlying observations. Paper presented at the Army Science Conference, June 1966.

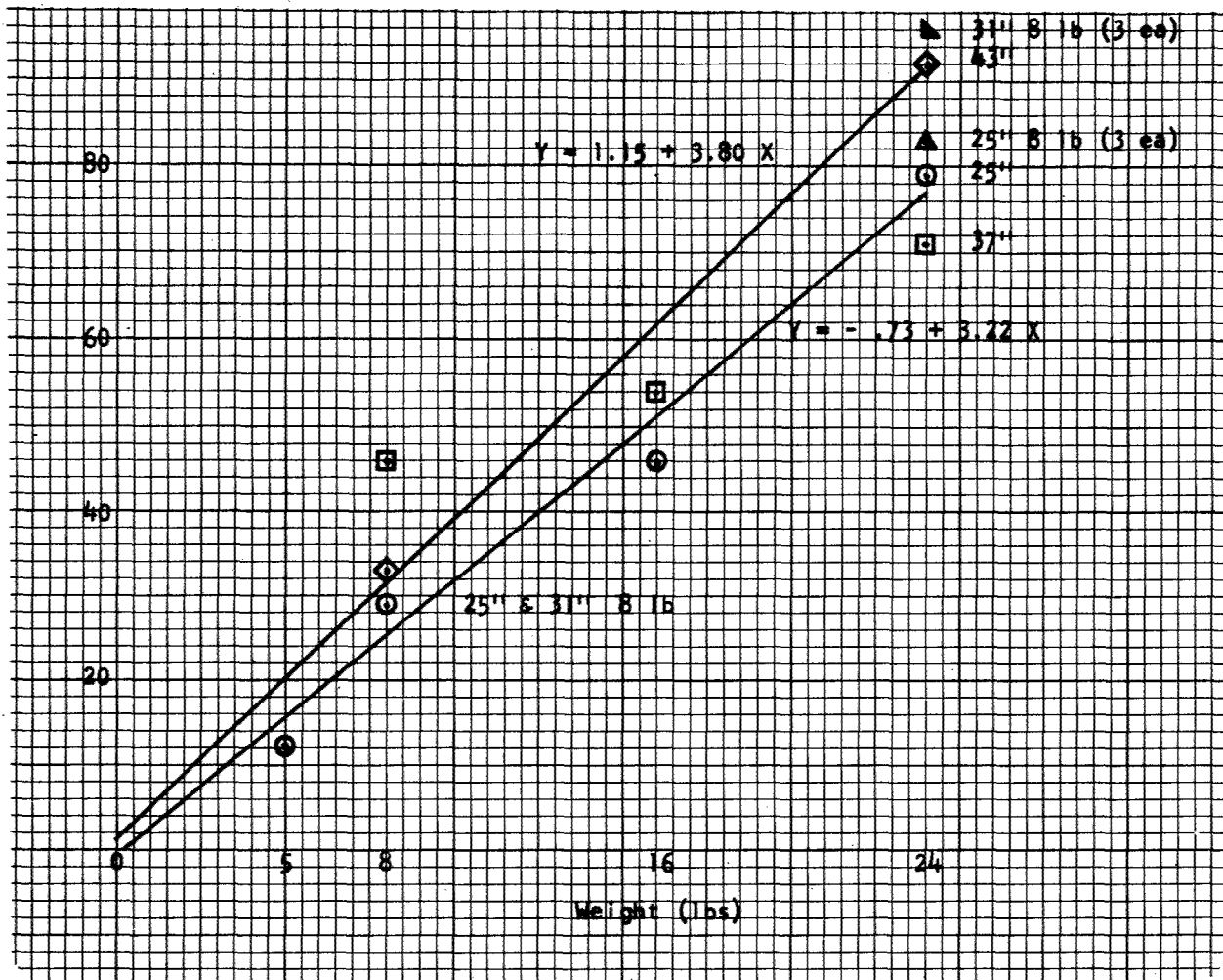


Fig. 5. Percentage of men not able to keep up with the slowest man at fighting load — not carrying antitank weapon versus weight.

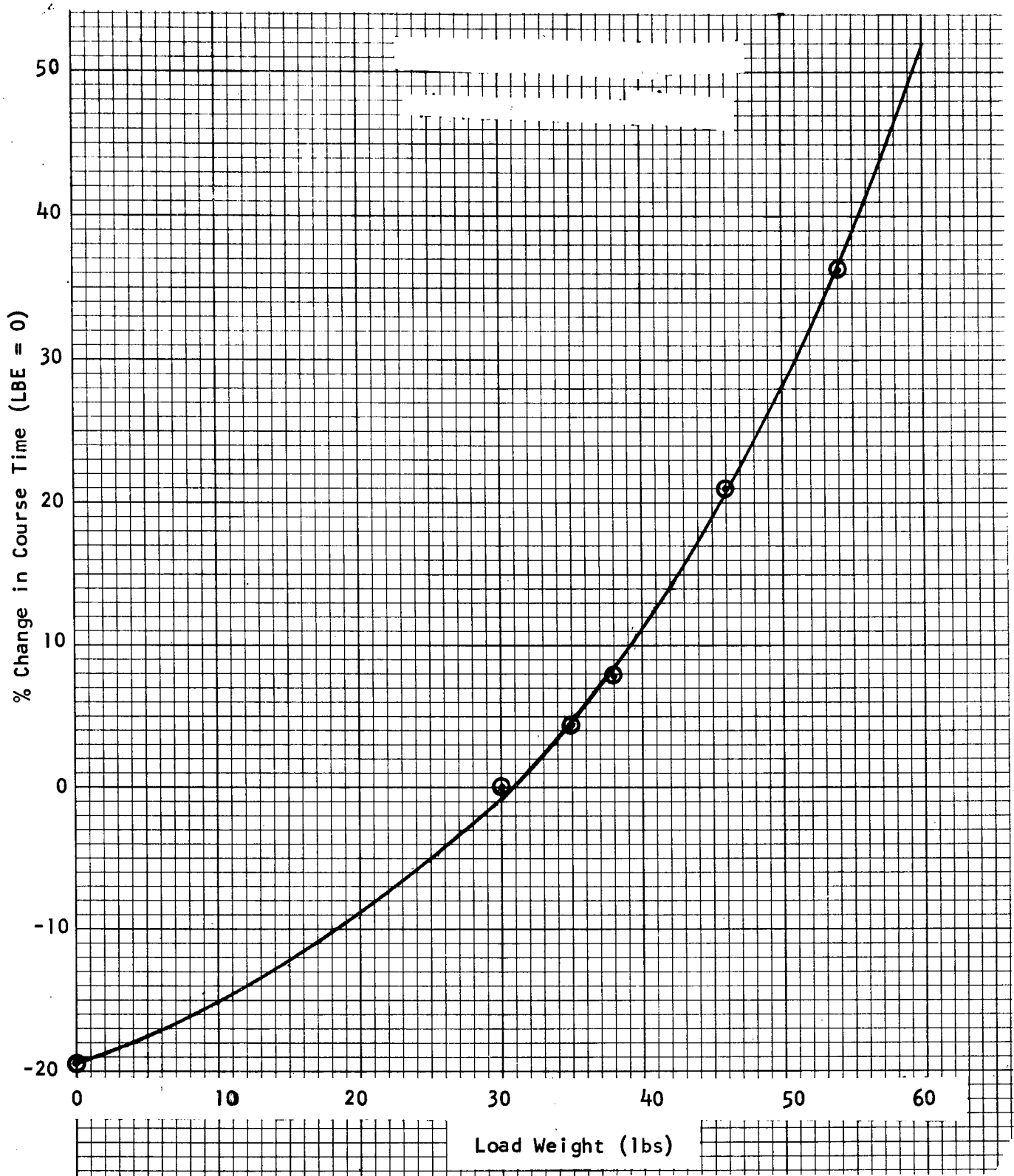


Fig. 6. Percent change in course time (LBE = 0) versus load weight.

Tracking Data

		Mean Radial Standard Deviation	
		Before	After
LAW/5 25	C	2.21	2.56
25/8	L	1.94	2.39
31/8	I	2.07	2.41
43/8	E	2.07	2.50
37/8	H	2.06	2.47
25/16	K	1.85	2.13
37/16	G	2.56	2.10
37/24	F	2.04	2.69
25/24	J	2.48	2.55
Three/8 25	A	2.10	2.59
43/24	D	2.42	2.26
Three/8 31	B	2.49	2.81
Mean		2.19*	2.46*
SD		.23	.20
LBE	Day: R	2.25	2.40
LBE	Day: R2	2.71	2.44
LBE	Day: R3	1.91	2.31
Mean		2.29	2.38

*Difference between means significant at .05 level
(t = 3.09)

TABLE 9

M14 Aiming Data

Mean x off before	1.989
Mean y off before	4.876
Mean x off after	1.705
Mean y off after	5.427
x Std. Dev. before	2.179
y Std. Dev. before	2.252
x Std. Dev. after	2.690
y Std. Dev. after	3.170
Radial Std. Dev. before	3.318
Radial Std. Dev. after	4.459

Digging

Table 4 shows the means and standard deviations of digging times for the 12 conditions plus the LBE trials. There do not appear to be any effects due to the differences in loads when examining the means and sigmas. There do not appear to be any trends; for example, carrying three 8-pound 31-inch systems produced about the same mean value as carrying the LAW. It is interesting to note that the types of demands placed on soldiers in good condition carrying the total weights, i.e., approximately 61 pounds that they did in this experiment, even repeatedly, do not seem to produce the anticipated fatigue as might be measured by a task such as digging.

Questionnaire Results

The first question the subjects had to answer after having carried a test weapon for a full day was, "In general, how would you rate the test weapon that you carried today with respect to its portability and ease of carry?" on a scale from one to five, ranging from "very easy to carry" to "very hard to carry." Using the bipolar adjective rating technique, Figure 7 presents the mean ratings given each condition by all subjects and Tables 1J through 4J in Appendix J present the means and standard deviations for the bipolar adjective ratings. Although an ANOVA was not done, it appears as though the conditions of test were well-ordered with regard to their mean ratings. The men were able to discriminate among systems.

Since the primary interest in the SMAWT program was with regard to the 8-pound systems, a "t" test for correlated means was performed on the 25-inch 8-pound, the 31-inch 8-pound and the 37-inch 8-pound systems, comparing them with the LAW. As can be seen from Table 1K, Appendix K, the mean rating for the 37-inch 8-pound load was significantly different from LAW.

It can also be seen from the slopes of the curves that when the loads became very heavy, they were so difficult to carry that it did not matter how long they were.

The important point, however, is the fact that all the 8-pound systems range from neutral to very easy to carry, whereas the 16-pound and 24-pound systems range from neutral to very hard. It seems as though it takes a weight heavier than 8 pounds to go from neutral to hard to carry.

It can be seen from Figure 8 that comfortable versus uncomfortable seems to be a discriminating adjective and the transition between neutral to uncomfortable apparently occurs beyond 31 inches in length and 8 pounds in weight for a 31-inch system.

"t" tests for correlated means were performed on the 8-pound 25-inch and 8-pound 31-inch loads and LAW data points. It can be seen from Table 1K, Appendix K, that the 25-inch 8-pound and 31-inch 8-pound loads were significantly different than LAW but were not yet rated uncomfortable.

A similar adjective, manageable, shown in Fig. 9 shows a similar transition at 31 inches and eight pounds.

Figure 10 presents the percentage of test soldiers who felt that particular loads caused parts of their bodies to become sore.

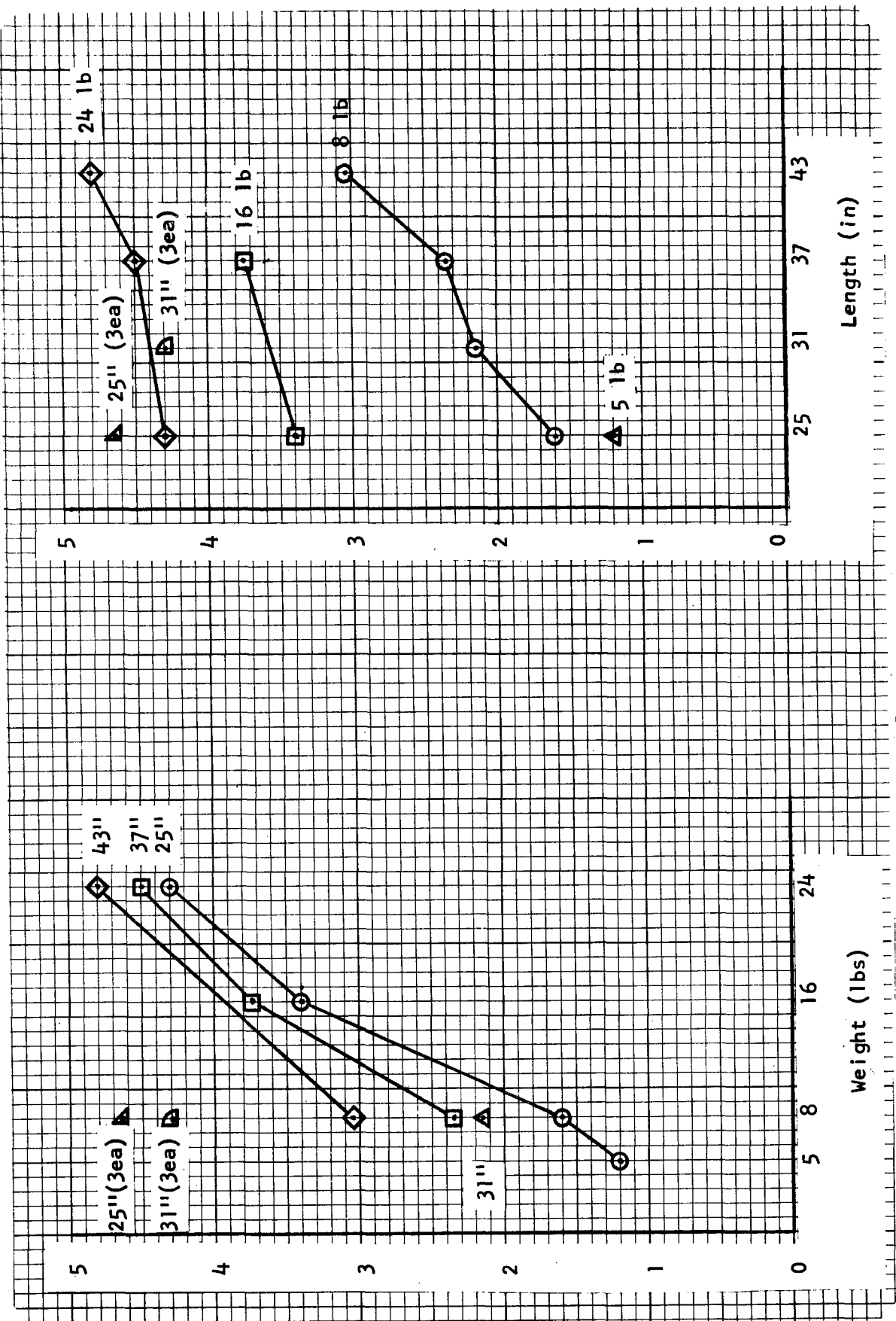


Fig. 7. Mean ratings given the adjective "ease of carry" by all subjects.

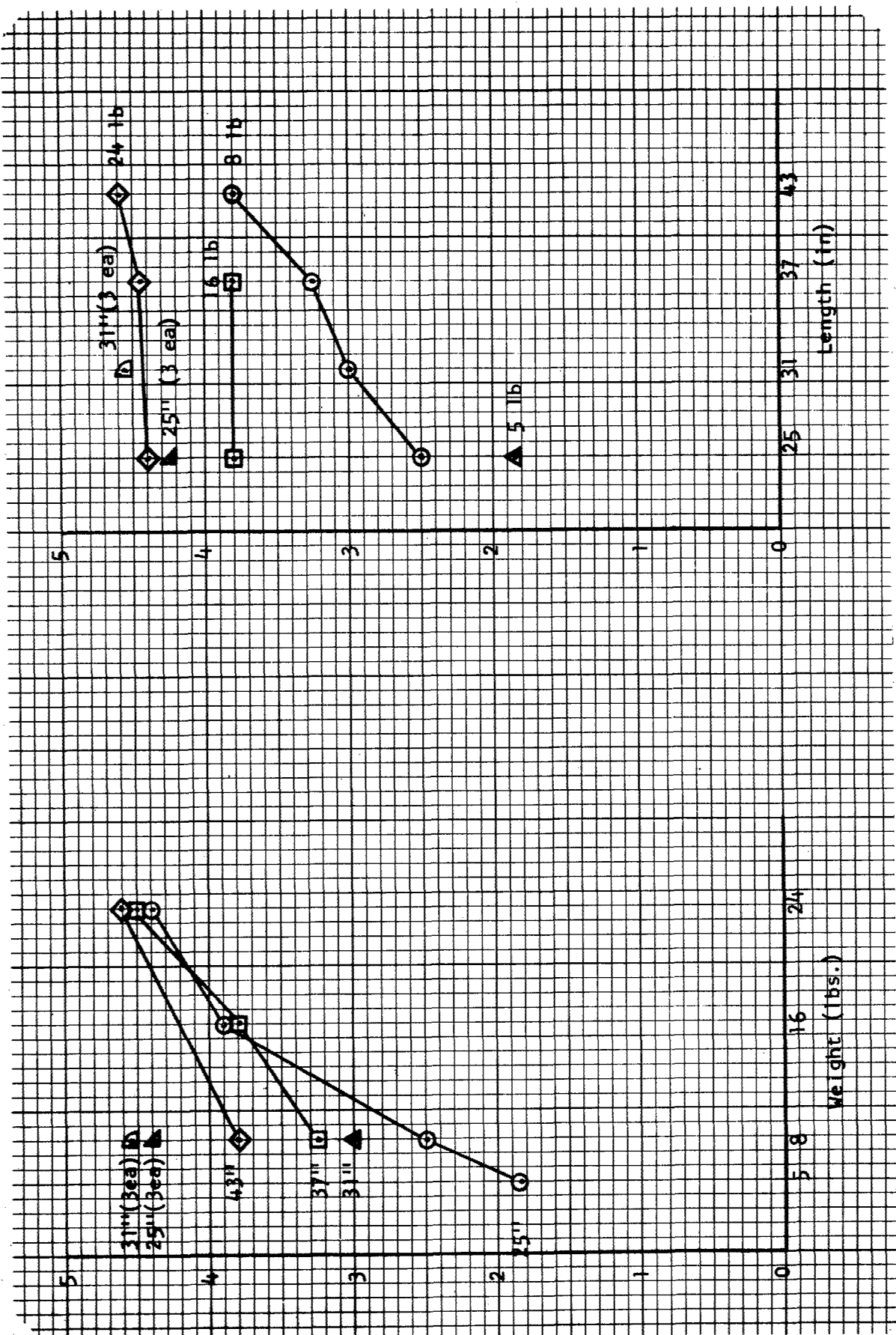


Fig. 8. Mean ratings given the adjective "comfortable" by all subjects.

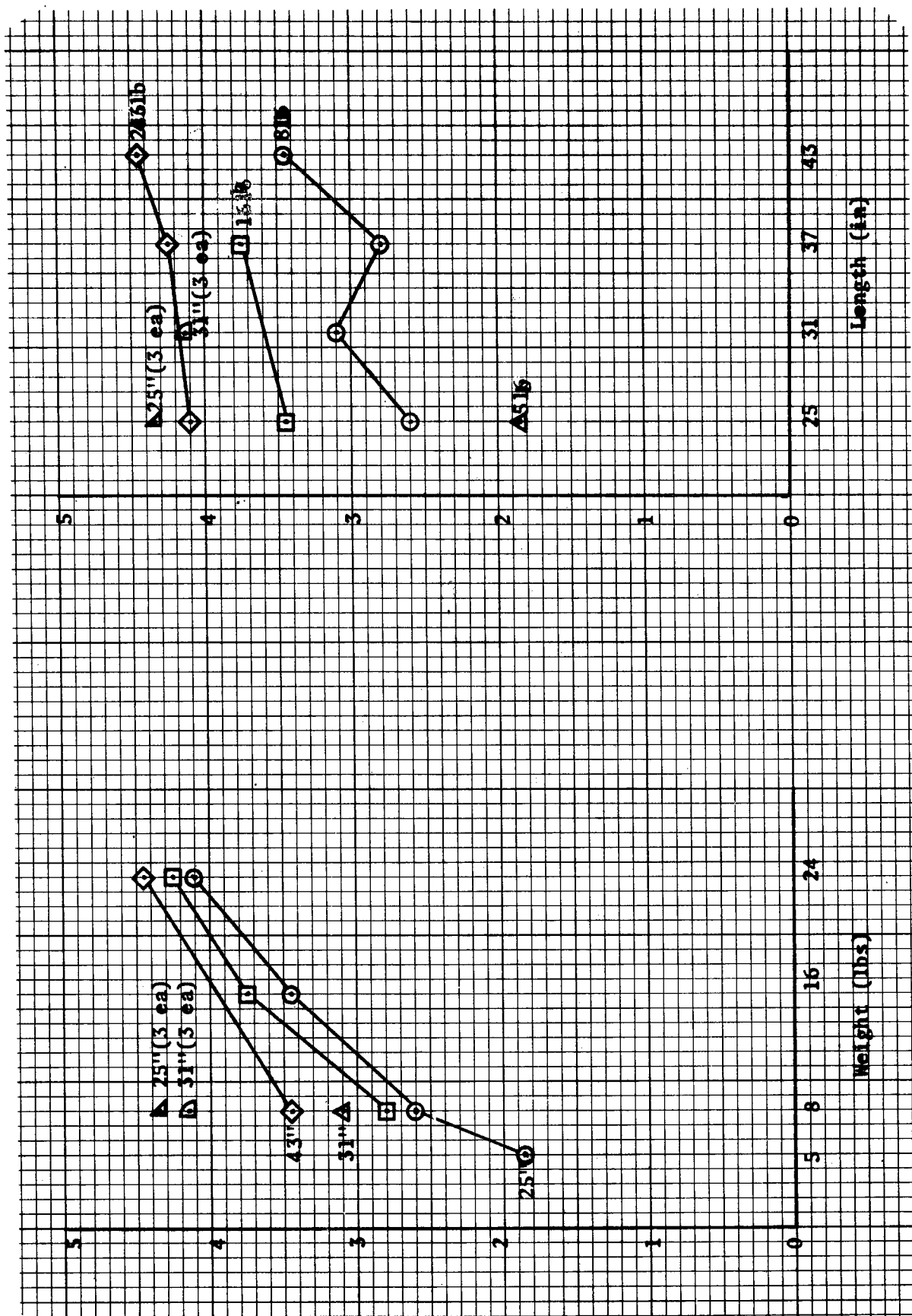


Fig. 9. Mean ratings given the adjective "manageable" by all subjects.

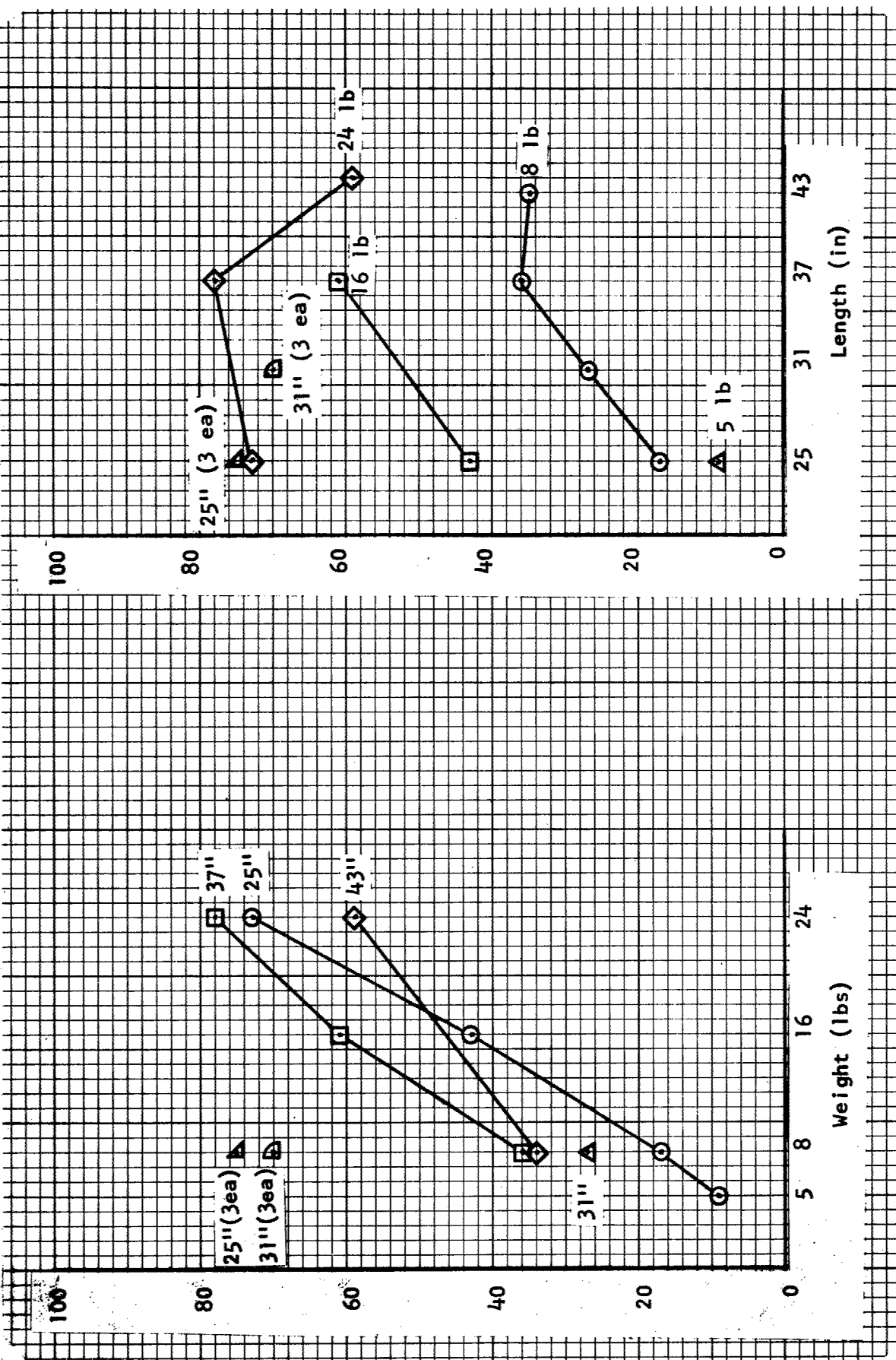


Fig. 10. Percentage of subjects who felt that particular loads caused parts of their bodies to become sore.

A chi-square test was performed on this data and comparing LAW with the 8-pound 25-inch, and 8-pound 31-inch and 8-pound 37-inch loads, the 8-pound 37-inch differed significantly from LAW at the .05 level while the others did not (Table 2K, Appendix K).

The above four bipolar adjectives (ease of carry, comfortable, produces soreness and manageable) were chosen not only because it appeared as though the results were well ordered and generally in consonance with the performance data, but because it was felt that together they constituted a factor that would be important in evaluating systems that soldiers would carry. It is believed that the factor could be thought of as a reluctance-to-carry factor.

The next two adjectives have to do with the subjects' rating of weight (heavy) and length (long) (Fig. 11 & 12). With regard to length, it seems as though the transition occurs at approximately 31 inches; for weight, in the order of 10 pounds.

The last adjective presented in Figure 13 is stable. What is apparent from this graph is the fact that none of the systems, except possibly LAW, was considered stable.

Tables 11L through 11L in Appendix L present the tabulated responses to the remaining questions within the questionnaire and the two additional questions which required the subjects to rank order the systems from easiest to hard to carry and to indicate which systems they absolutely would not carry into combat. It was difficult to interpret the meaning of this last question because it was felt that the men may have been put on-the-spot, in the sense that the question worded in the manner in which it was may have been interpreted as measuring insubordination rather than reluctance to carry.

Parachuting

Appendix C is a trip report by Captain Charles Matts who also acted as the Test Officer in this experiment. A description of the events which occurred at the Airborne Department of the Infantry School is documented. The important conclusions to be drawn from the limited test conducted is the fact that a parachutist cannot do a proper parachute landing fall with the 43-inch system in the weapons container. Figure 1C (Appendix C), shows the 43-inch system in the weapons container. Upon reviewing the films obtained subsequent to the test, it was found that even though the 37-inch system was capable of being jumped from the 250-foot tower without difficulty, it was accomplished by a large man. Although not tried, it may well be that small men would also have difficulty with the 37-inch tube.

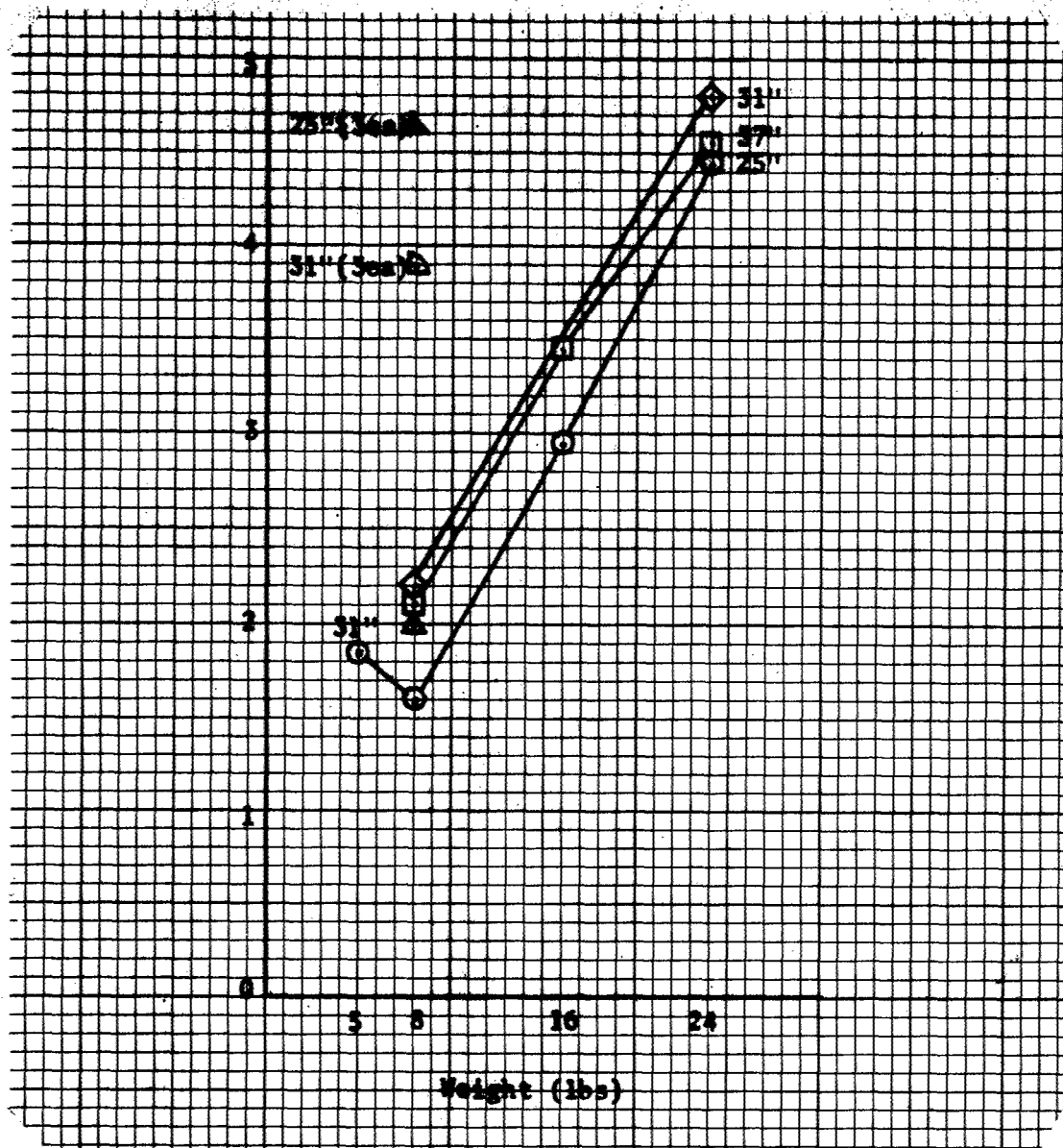


Fig. 11. Subjects' rating of weight.

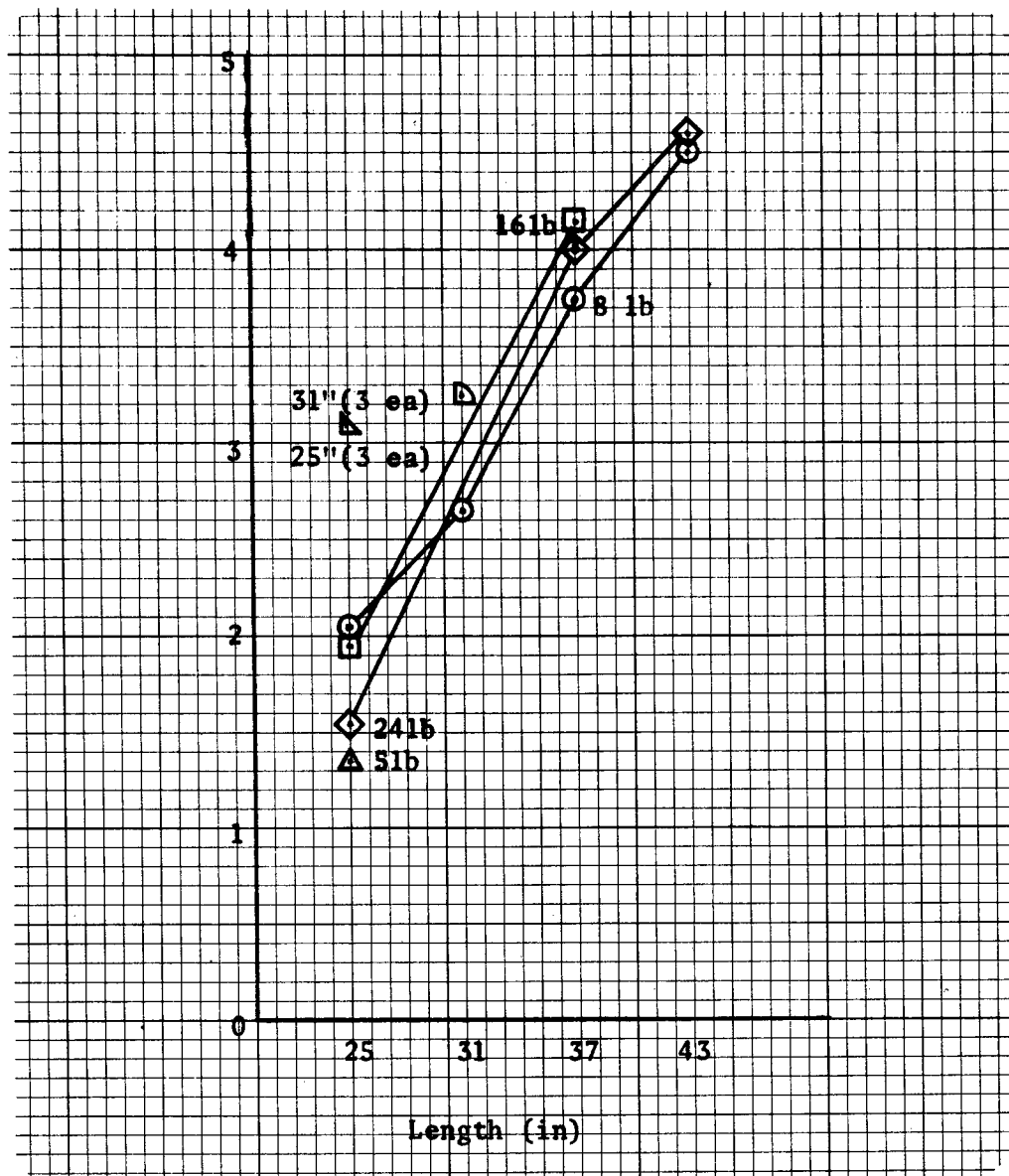


Fig. 12. Subjects' rating of length.

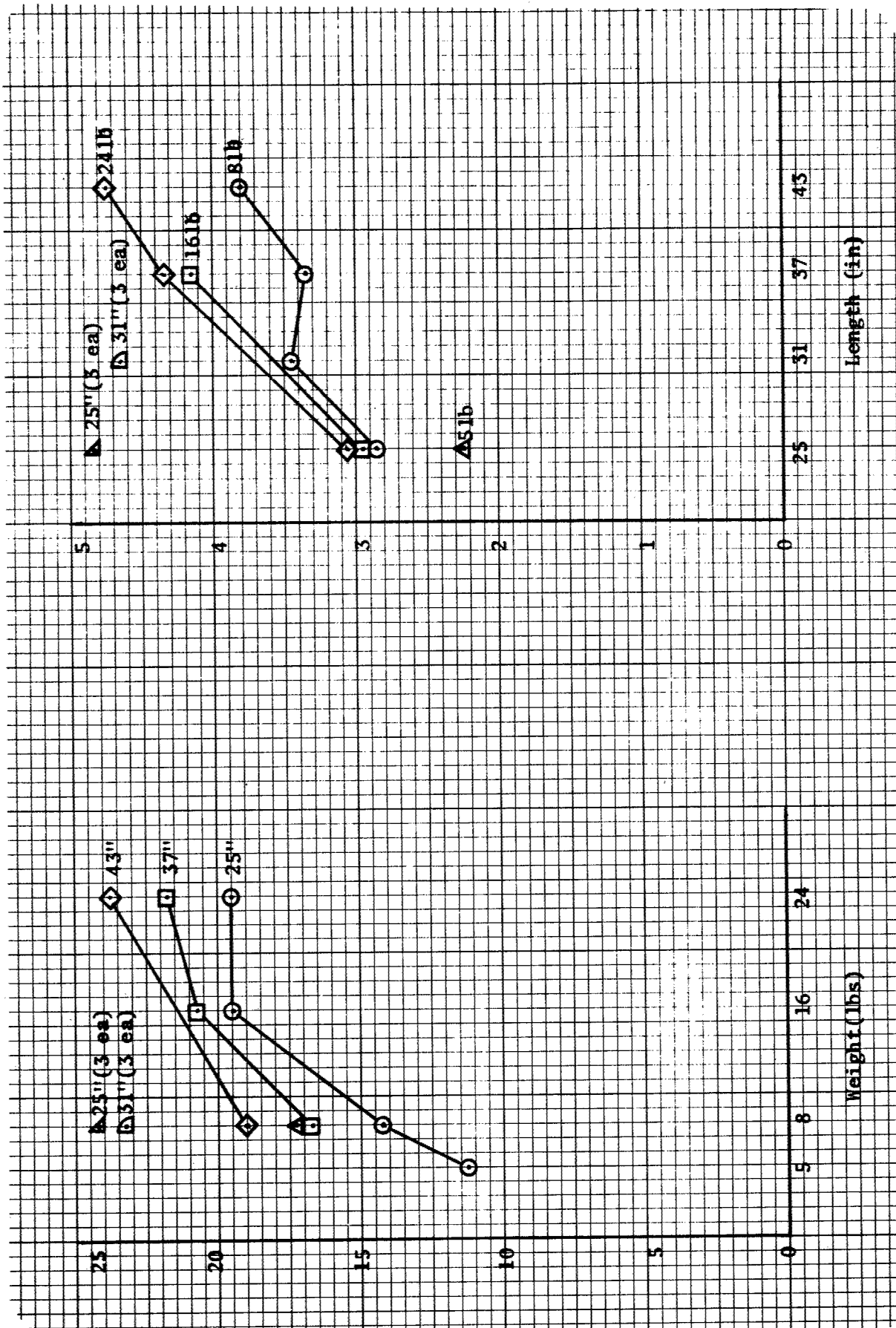


Fig. 13. Subjects' rating of stability.

Discussion of Results

Functional relationships are provided between weight, length and percentage change in course time. These relationships can be used in a trade-off manner by designers and systems analysts. Either the analyst or the infantryman can use these relationships with regard to scenarios of interest, whereby time and the accomplishment of various tasks are the dependent variables. The dimension volume (multiply carry), although not treated within the text in any detail, is a factor and can be applied with a little logic to combinations of weight/length parameter values.

It is believed that the percentage of men able or not able to carry a particular load is also a good trade-off method useful to the systems analyst or infantryman applying it to various scenarios where numbers of systems versus weight of munitions needed to be carried are important.

The apparent factor, reluctance to carry, also discriminates among loads and can be used in the trade-off manner.

The data, in general, can be applied to systems other than those falling within the SMAWT category.

It is interesting to note that although tracking and aiming performance tend to degrade after strenuous activity for the values tested, they do not appear to be associated with the parameter values of SMAWT.

With regard to the SMAWT category, it appears as though lengths greater than 31 inches and weights beyond 8 pounds would produce a significant degradation in the infantry rifleman's performance if added to his current fighting load.

CONCLUSIONS

1. Functional relationships between weight, length and performance were obtained with an indication of the effects of volume; i.e., multiple carry.
2. The test soldiers were able to discriminate among the loads using the bipolar adjective rating technique and for what appeared to be a reluctance-to-carry factor, tended to rate the loads carried in a manner which parallels the performance findings.
3. The infantryman's performance degraded and he was reluctant to carry 81mm antitank systems longer than 31 inches (at eight pounds) and heavier than 8 pounds when added to his current fighting load.
4. A proper parachute landing fall cannot be accomplished with a system 43 inches long in the weapons container.

RECOMMENDATIONS

It is recommended that 81mm antitank systems to be carried by the infantry rifleman not exceed 31 inches in length and 8 pounds in weight.

It is also recommended that particular attention be paid to improving the means of carry in the design of future weapons..

APPENDIX A

CROSS-COUNTRY ROAD MARCH

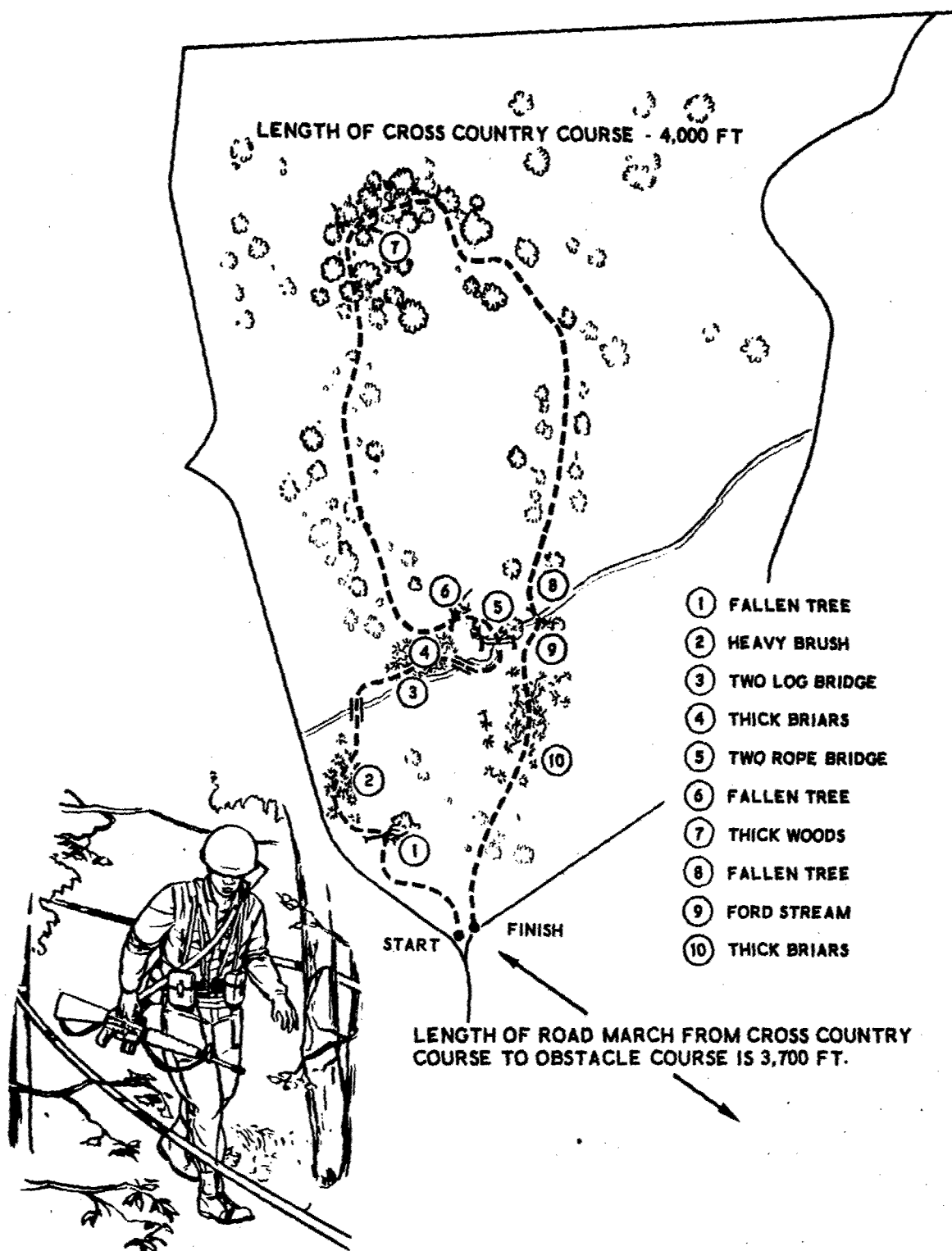


Figure A-1. Cross Country-Road March.

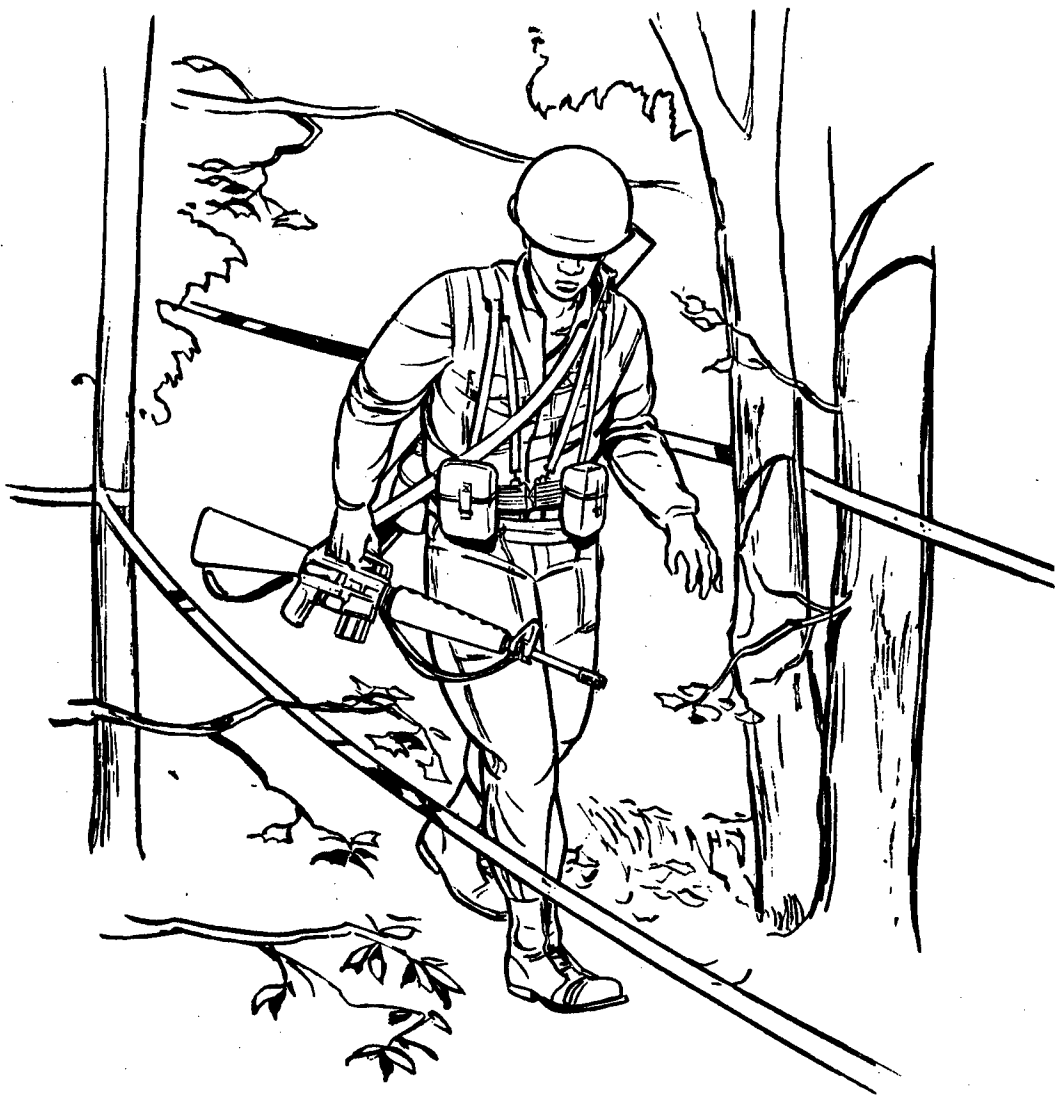


Figure A-2. Cross Country

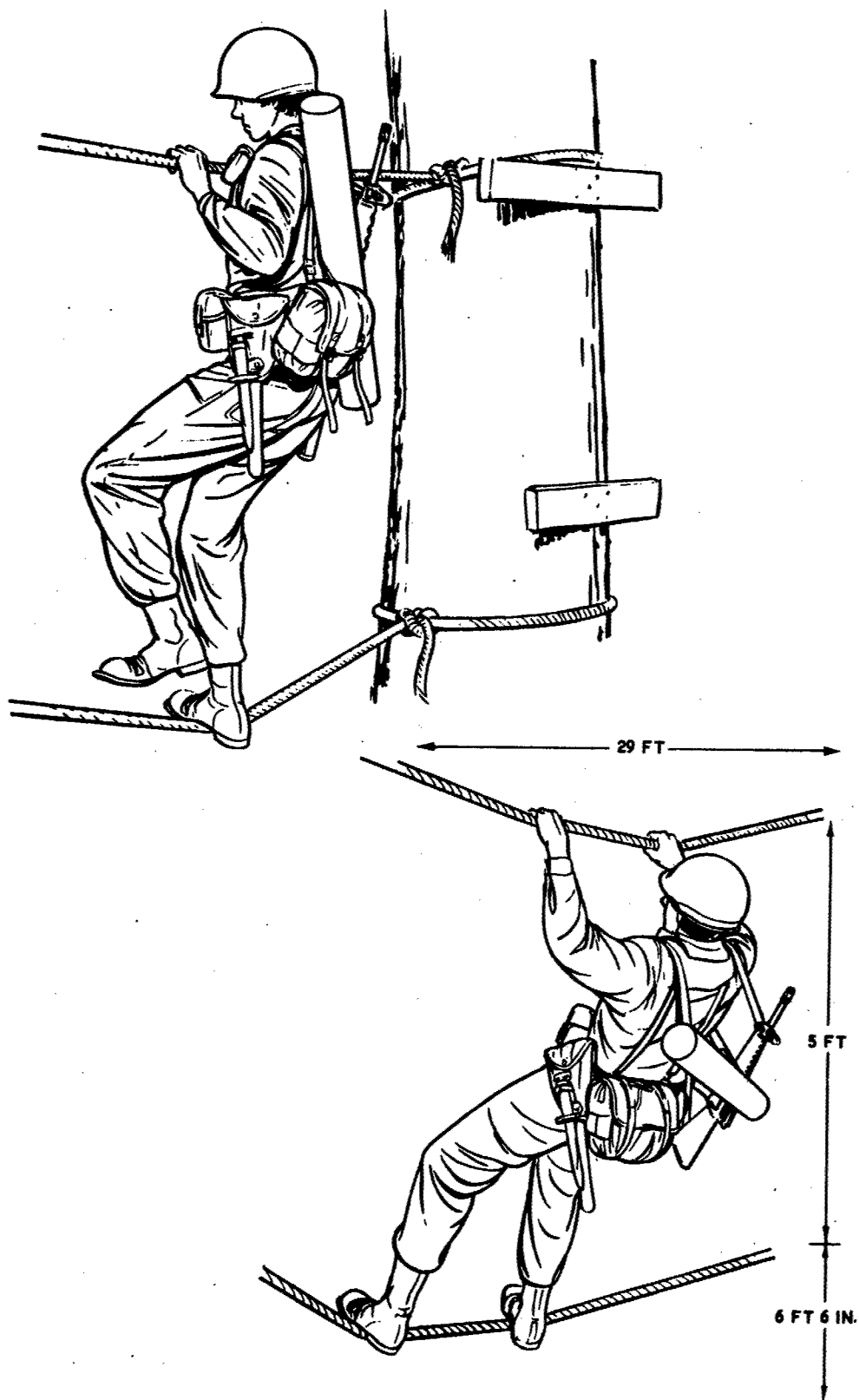
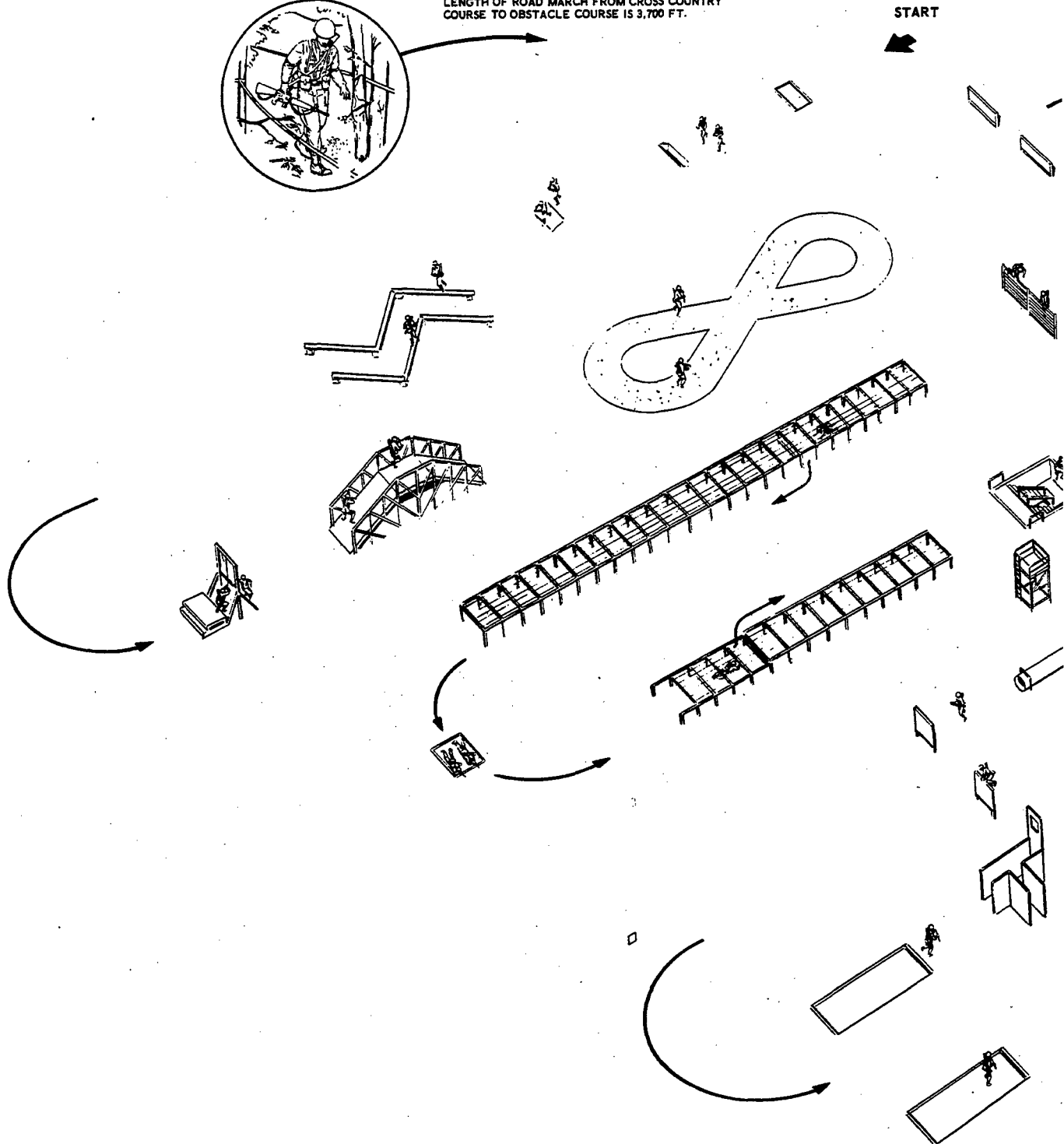


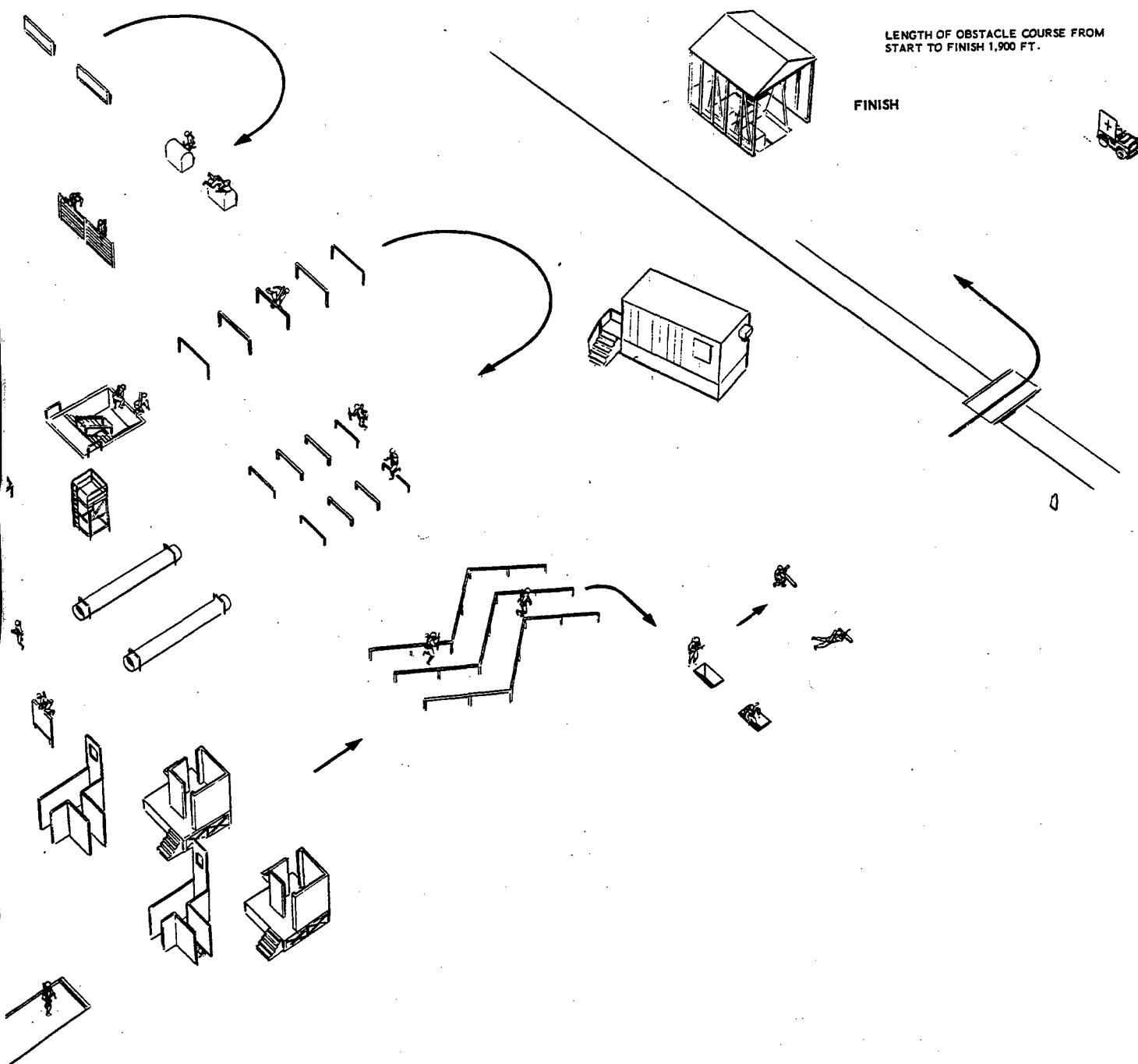
Figure A-3. Two-Line Rope Bridge



LENGTH OF ROAD MARCH FROM CROSS COUNTRY COURSE TO OBSTACLE COURSE IS 3,700 FT.

START





LENGTH OF OBSTACLE COURSE FROM
START TO FINISH 1,900 FT.

FINISH

Figure A-3B. Obstacle Course

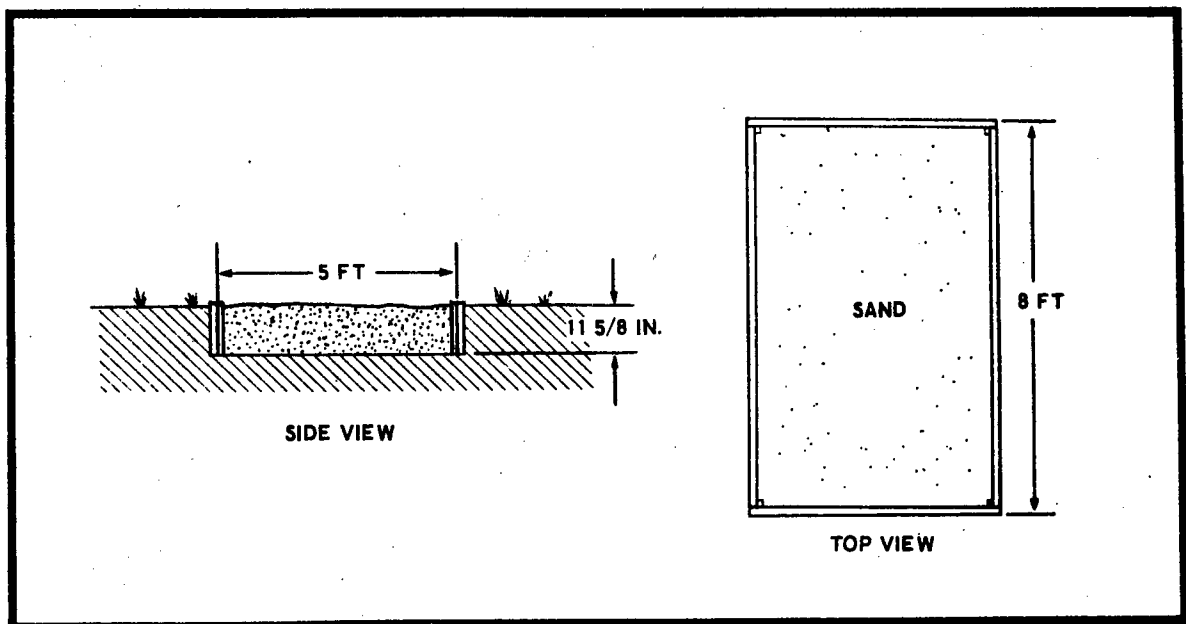


Figure A-4. Broad Jump

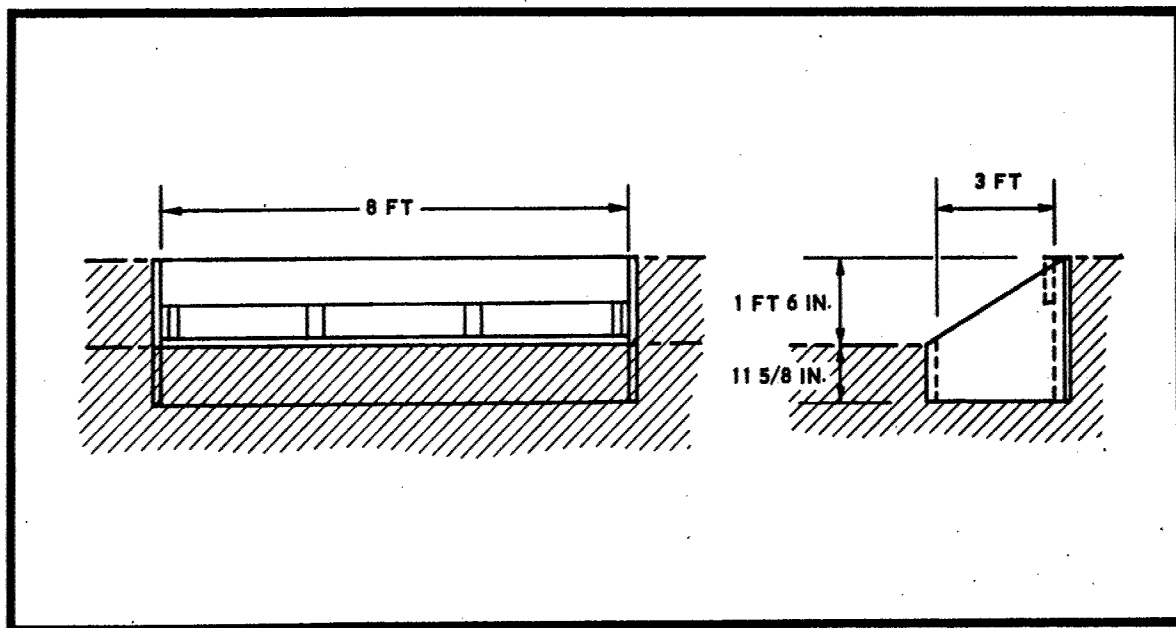
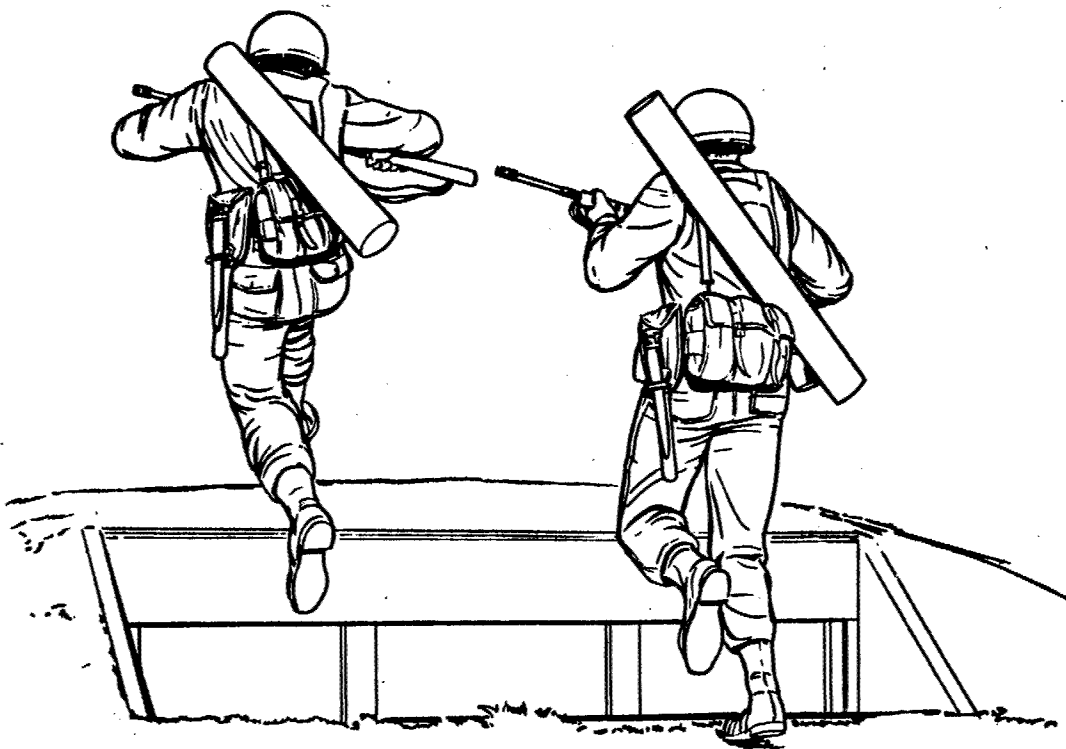


Figure A-5. Jump Up

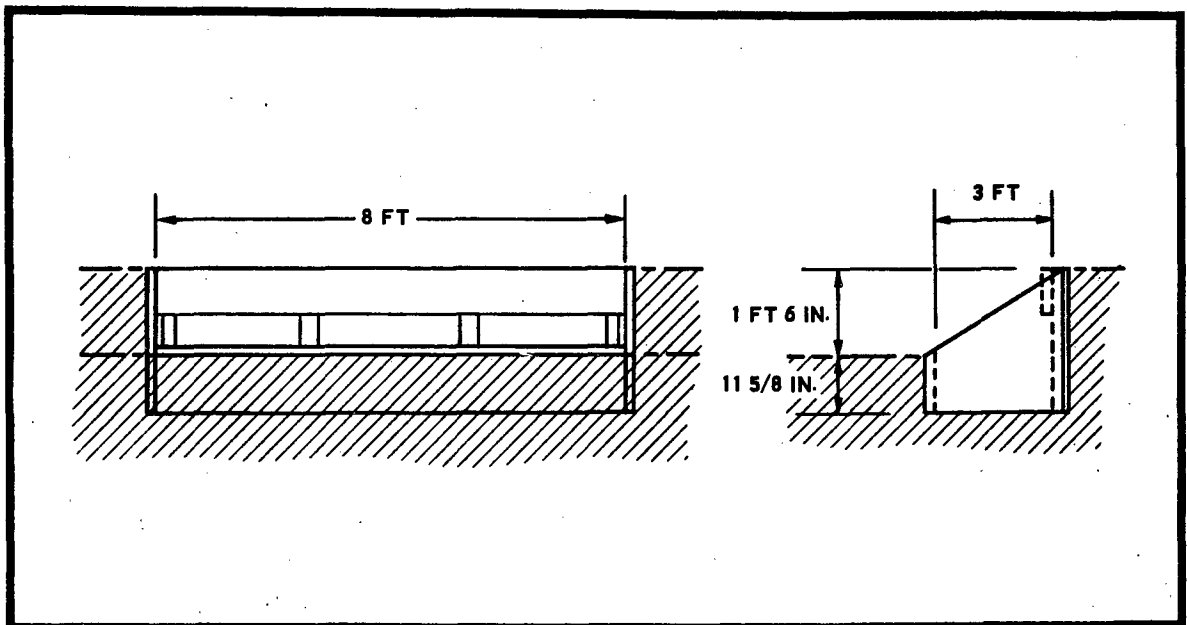


Figure A-6. Jump Down

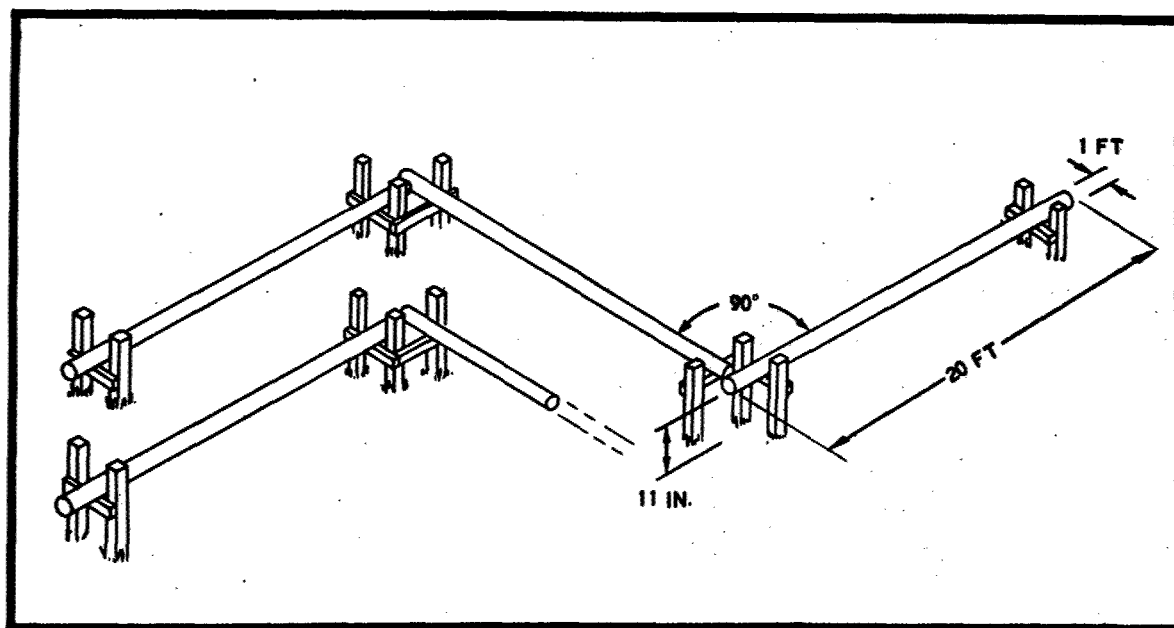


Figure A-7. Log Balance

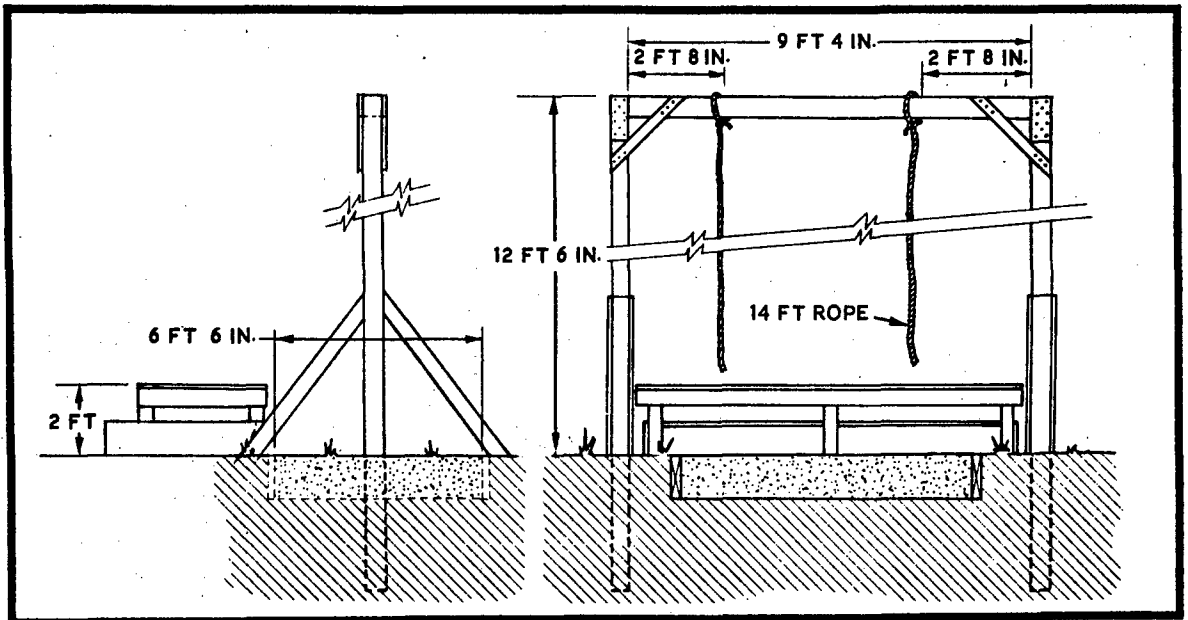
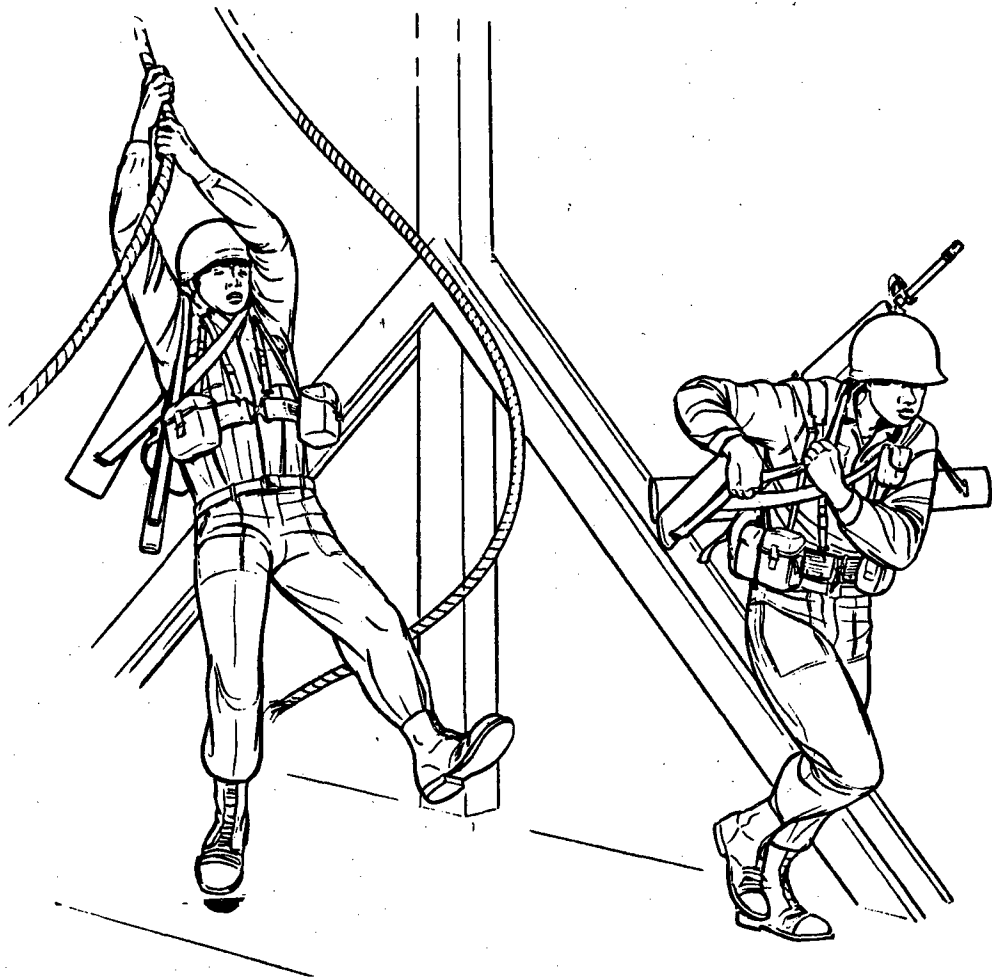


Figure A-8. Rope Swing

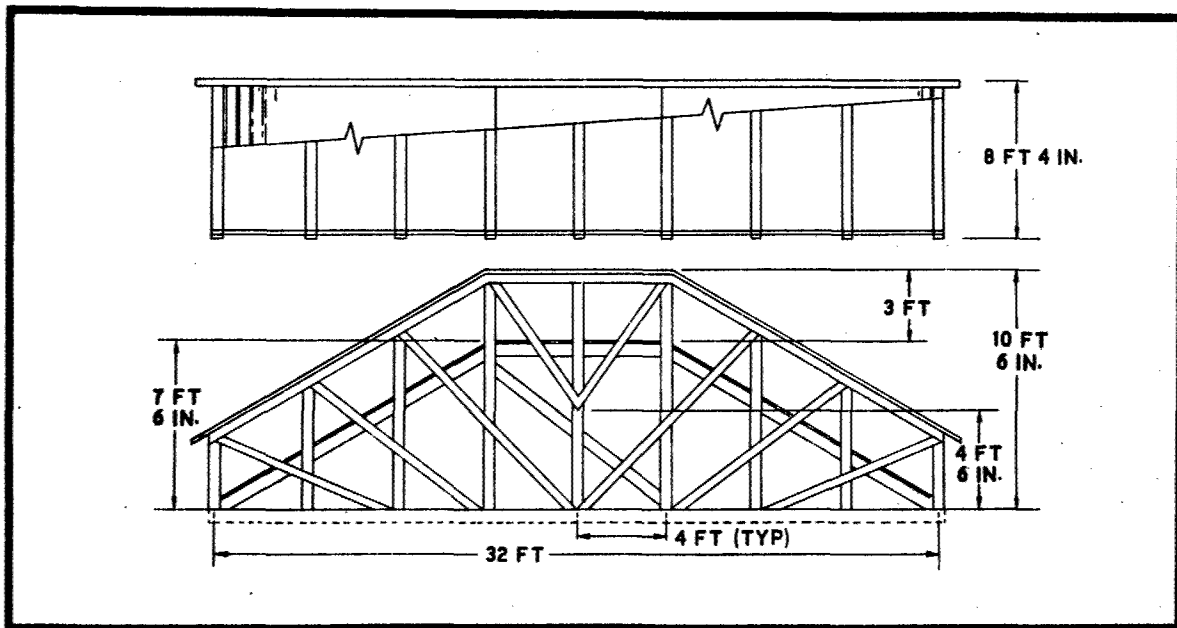
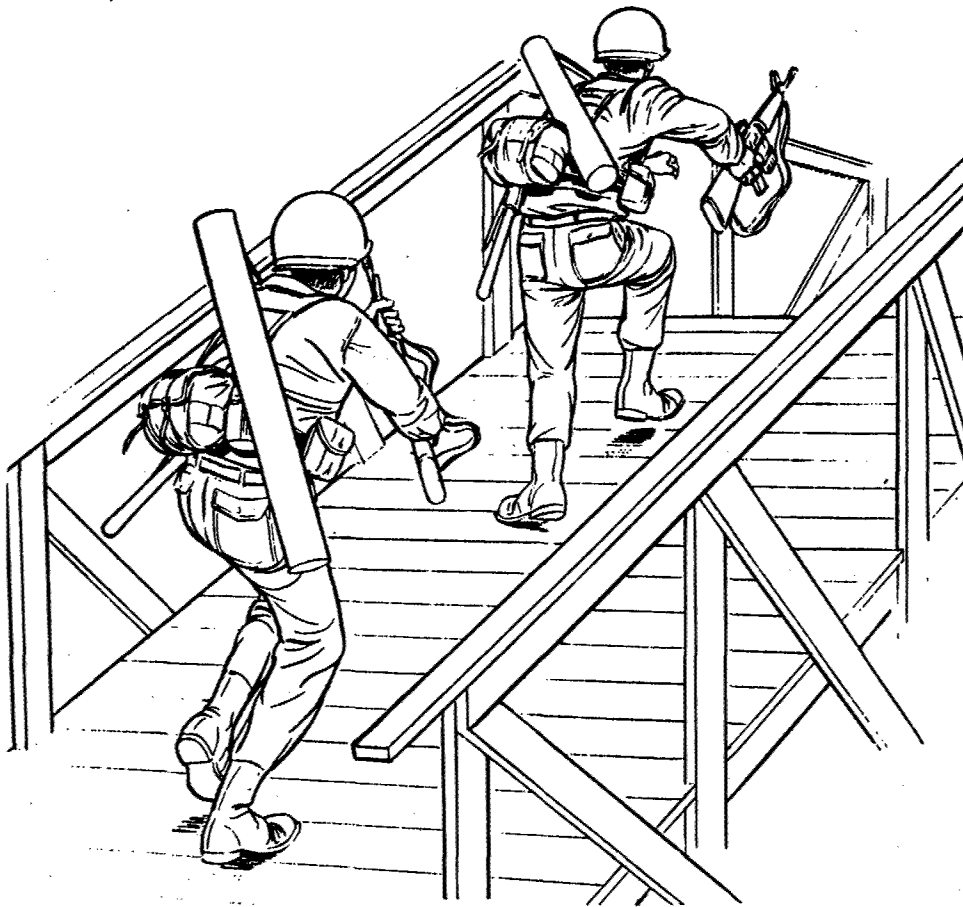


Figure A-9. Up and Down

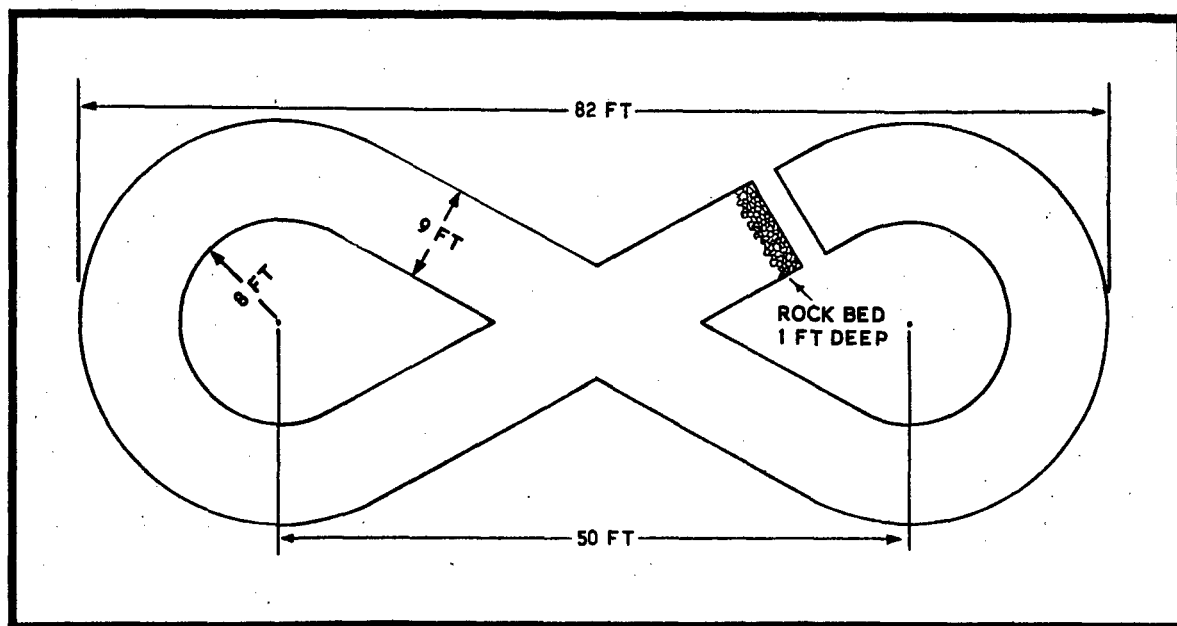


Figure A-10. Rock Bed

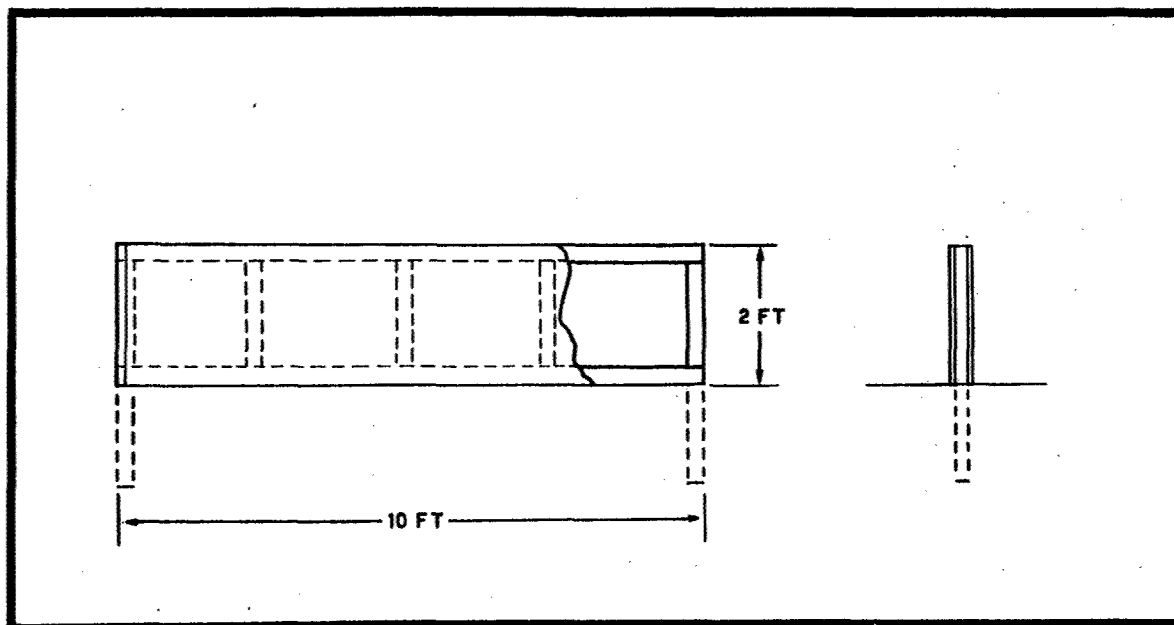
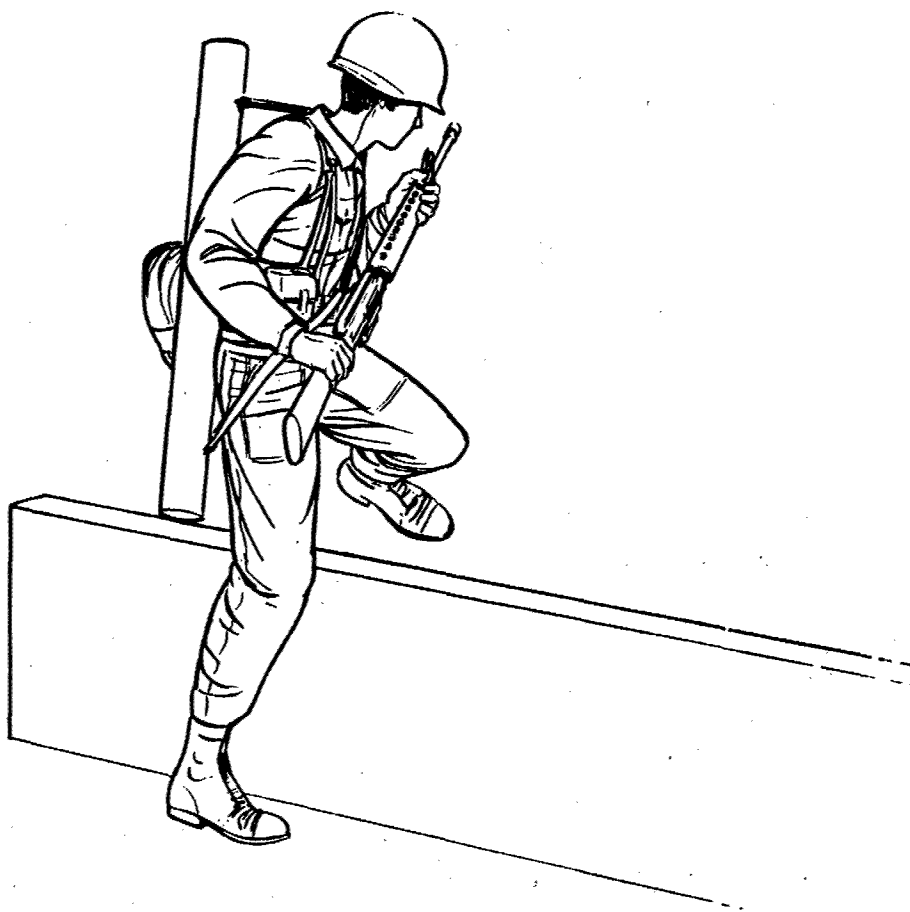


Figure A-11. Low Wall

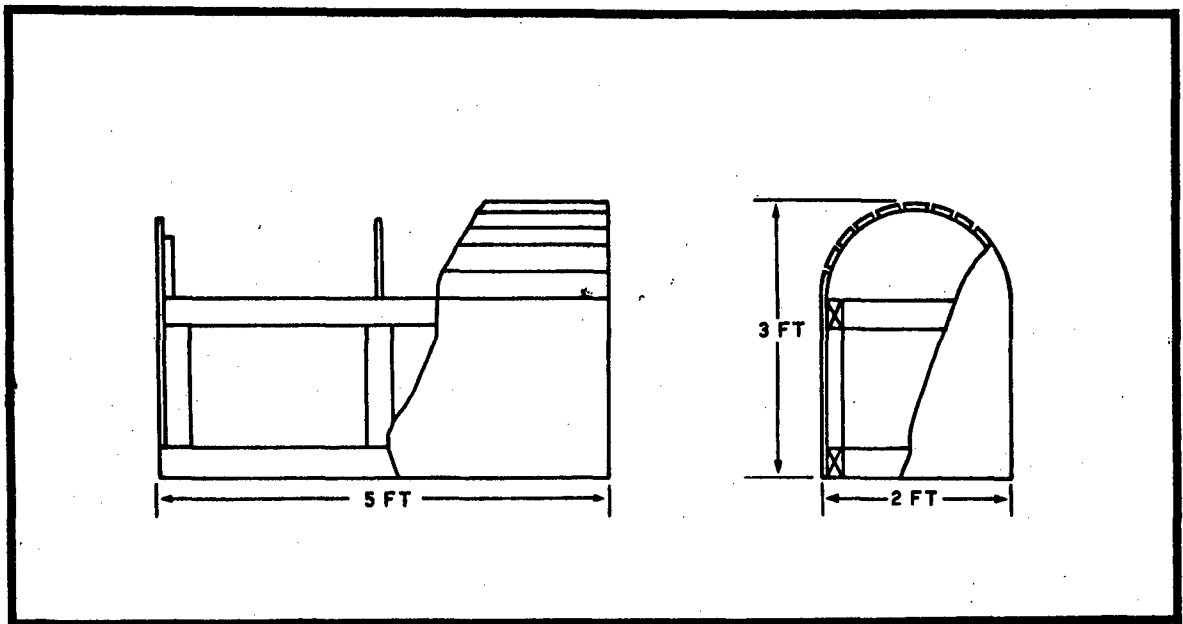
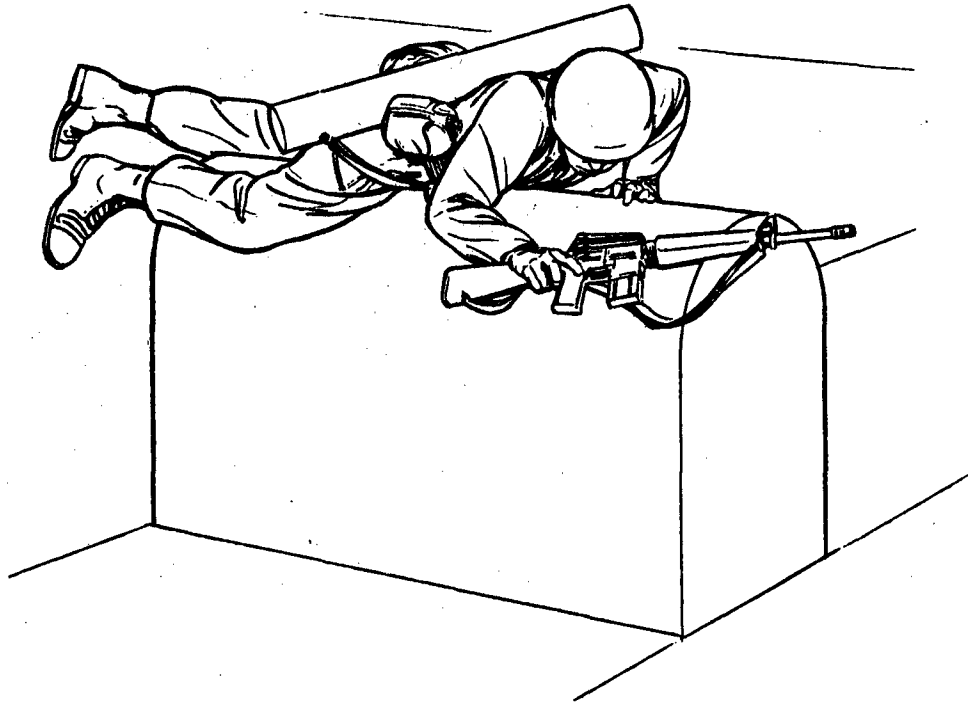


Figure A-12. Belly Buster

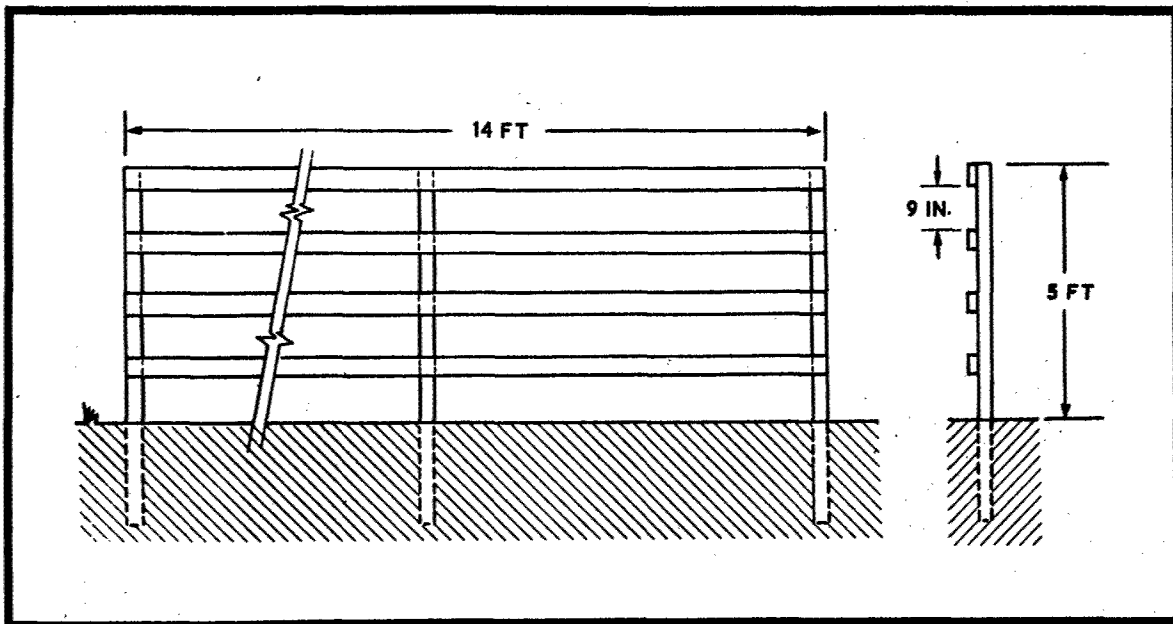
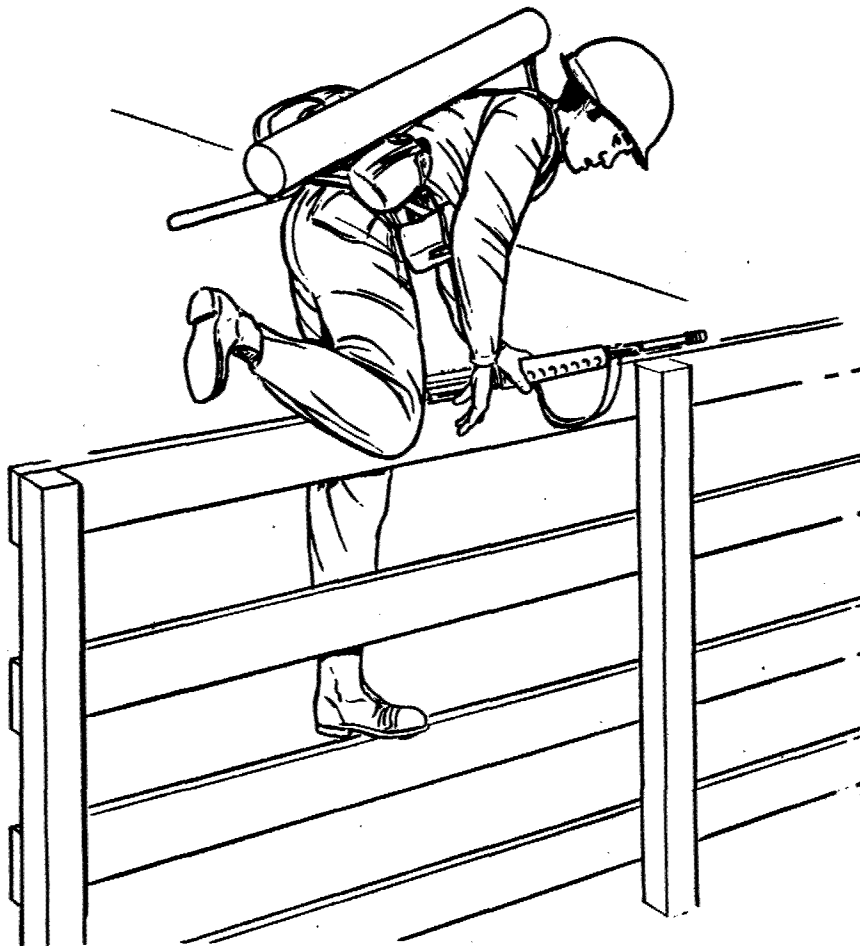


Figure A-13. High Fence

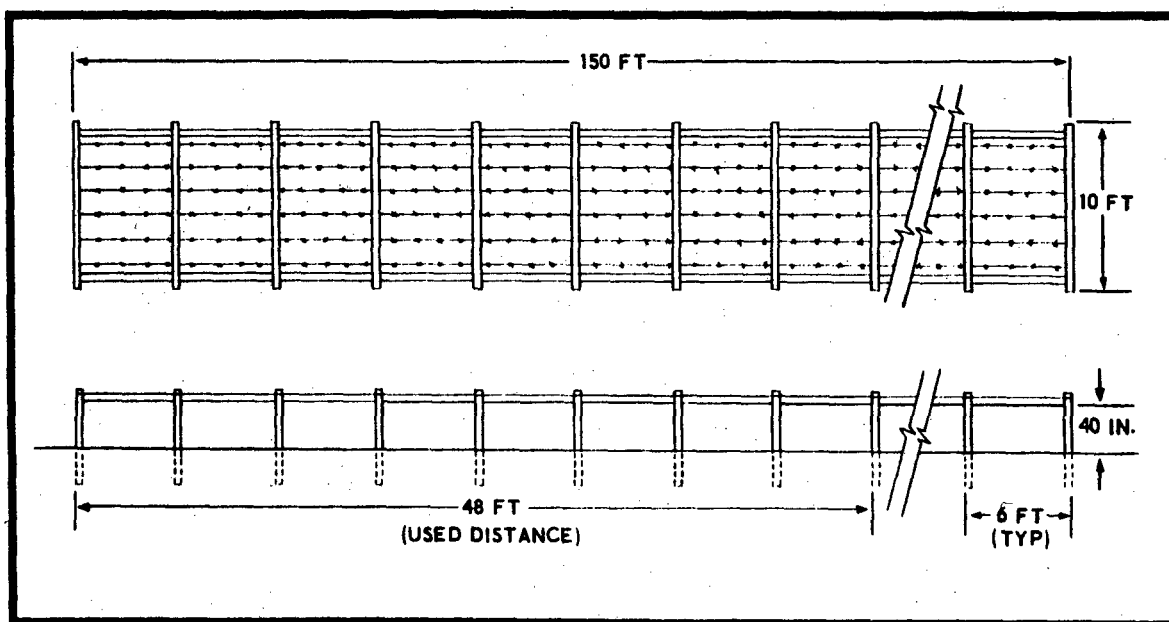
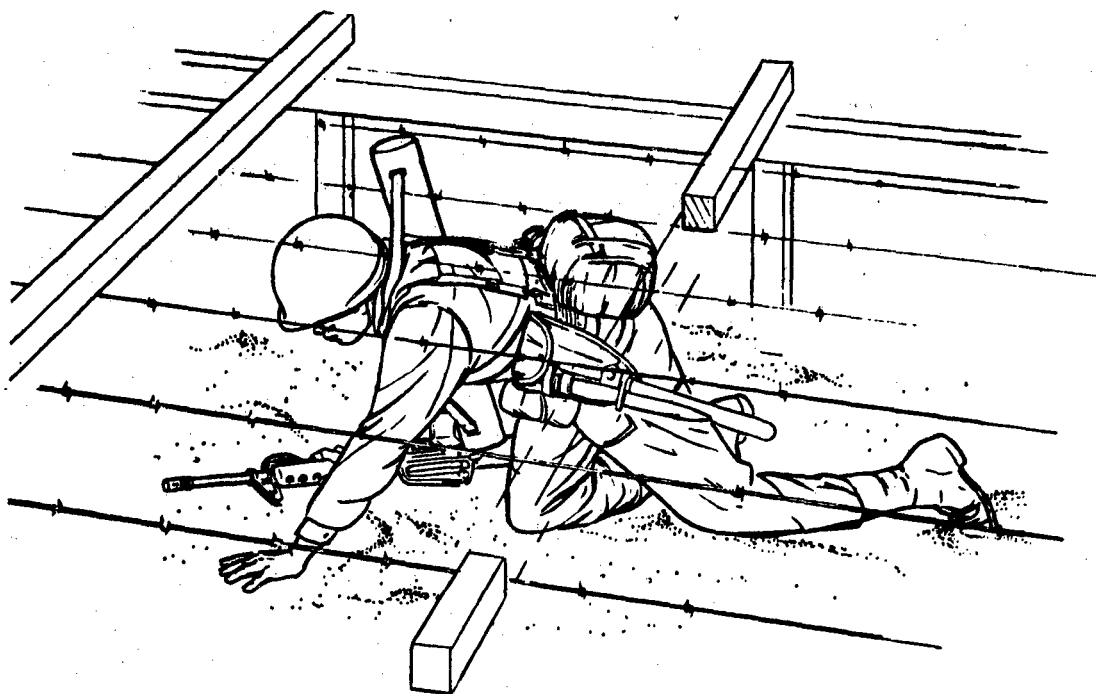


Figure A-14. High Crawl

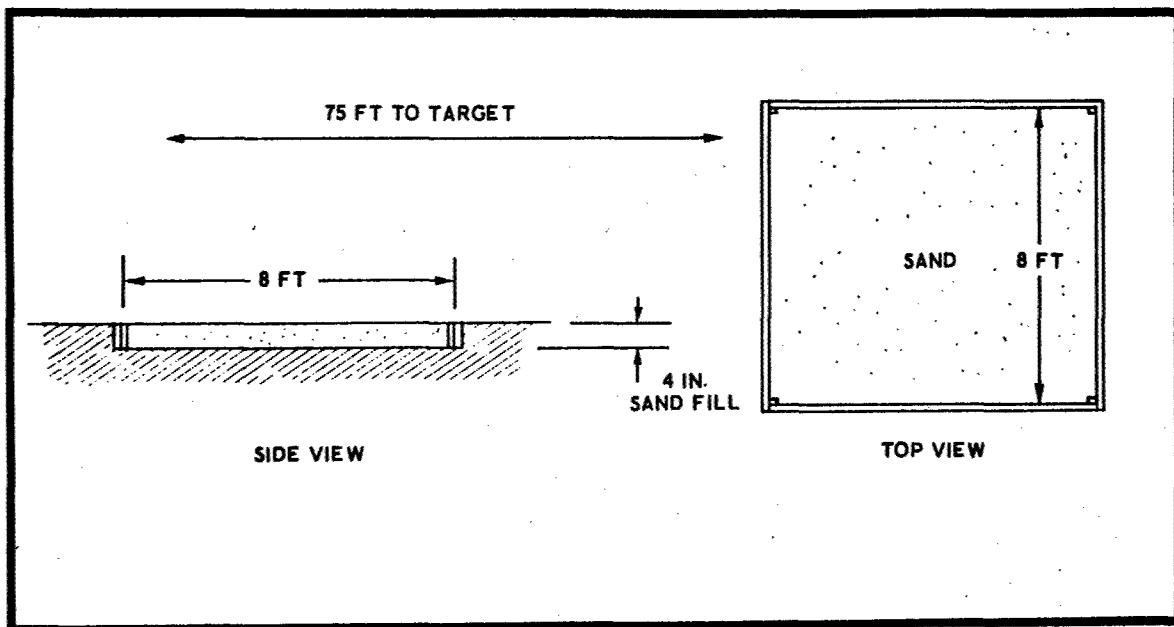
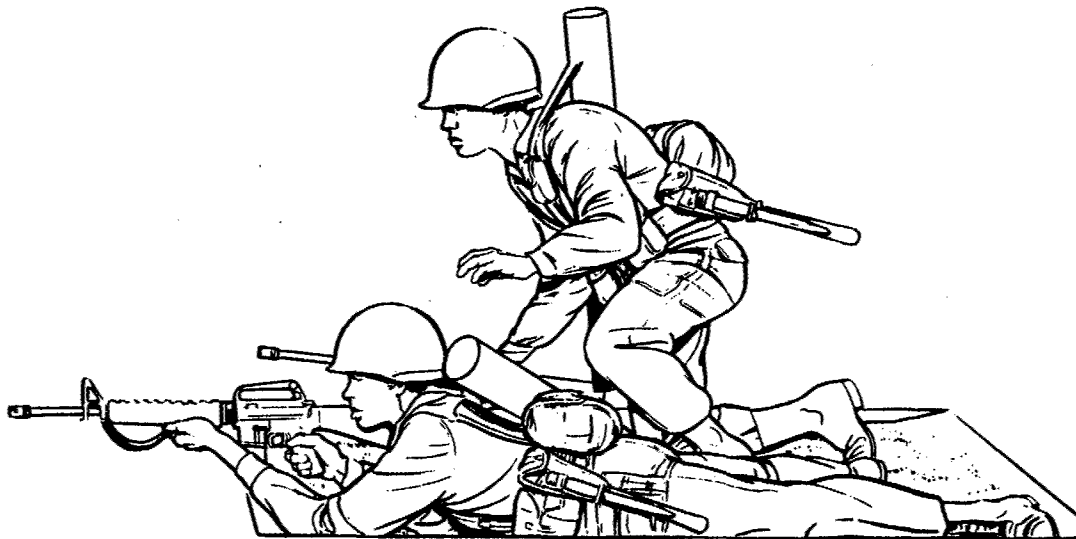


Figure A-15. Simulated Firing - Charging - Reloading

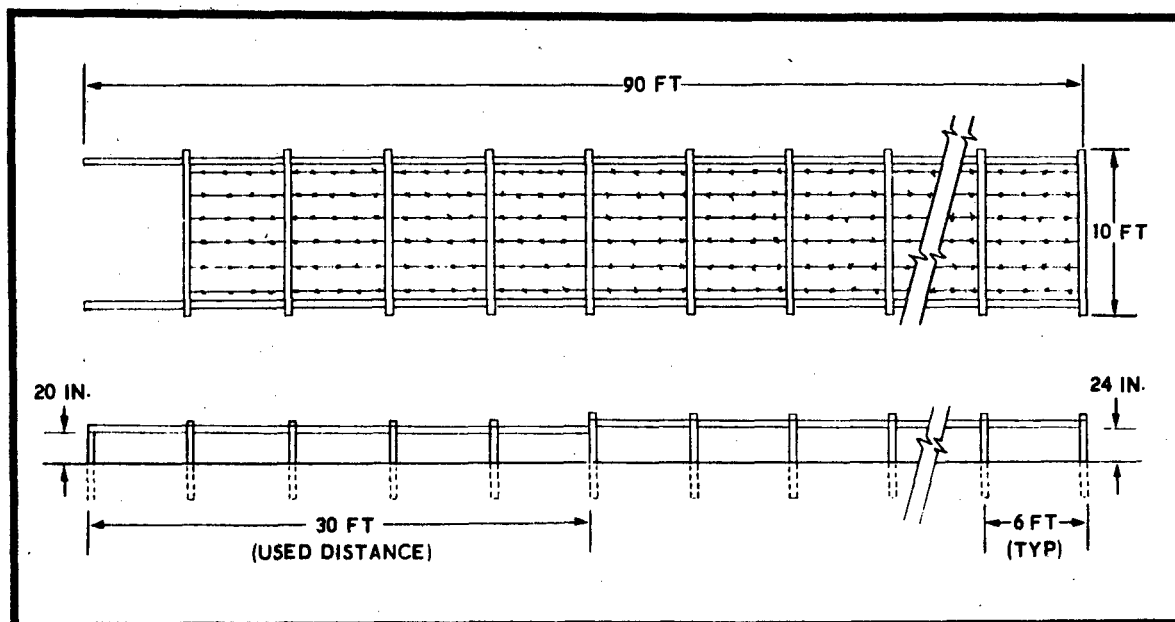
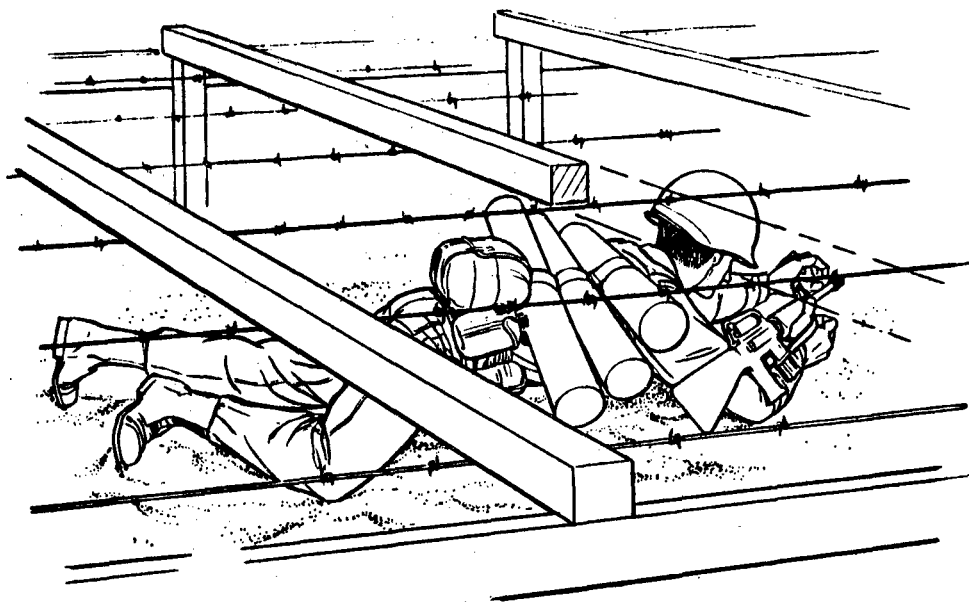


Figure A-16. Low Crawl

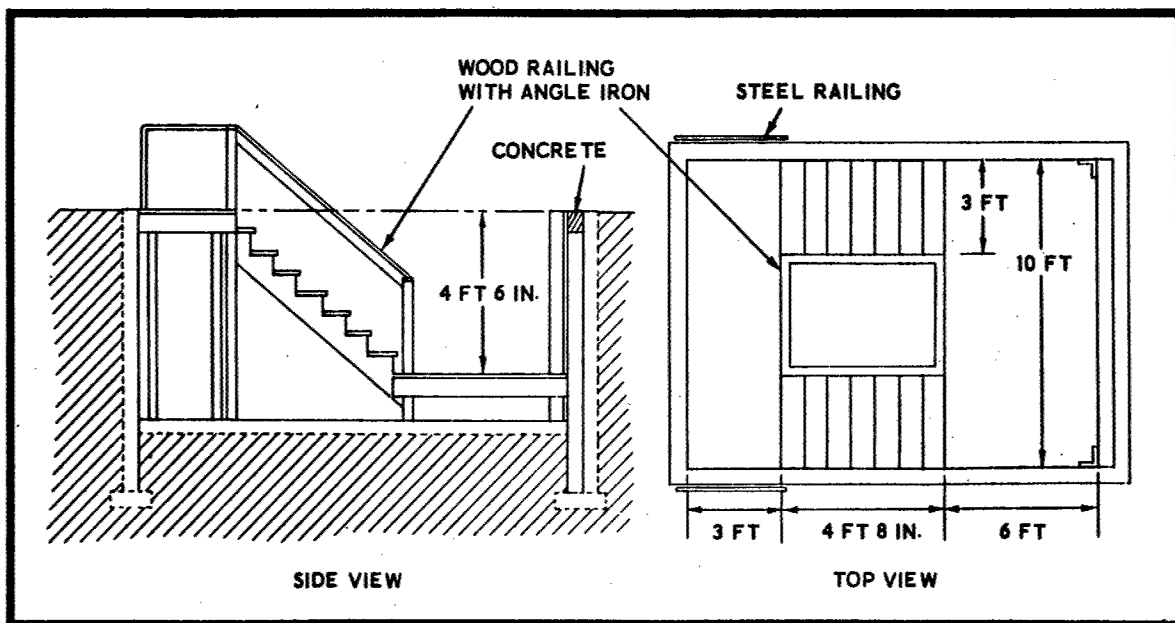
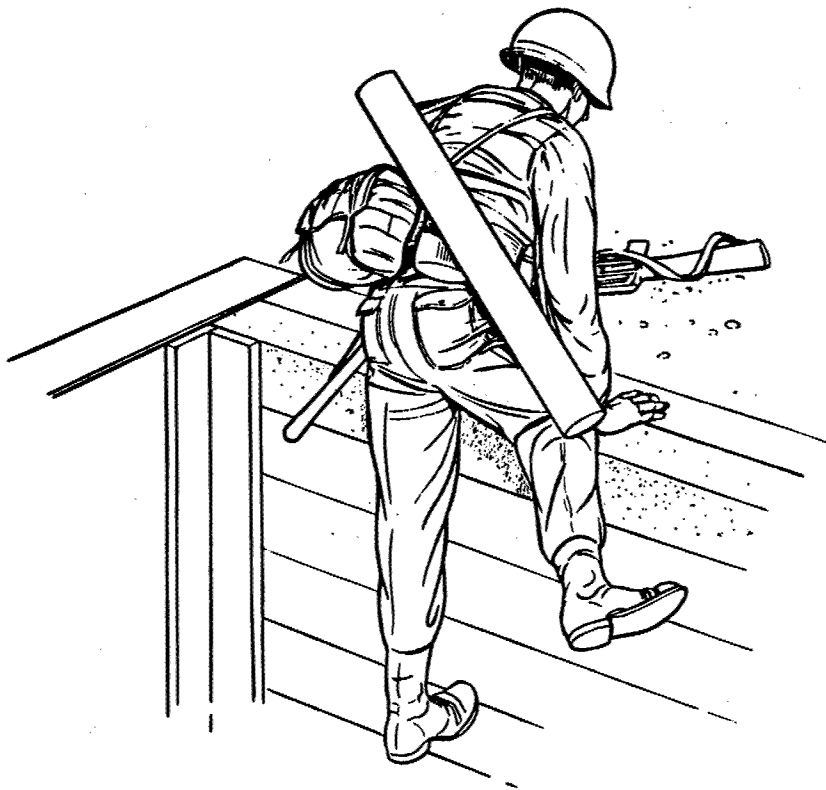


Figure A-17. Down and Out

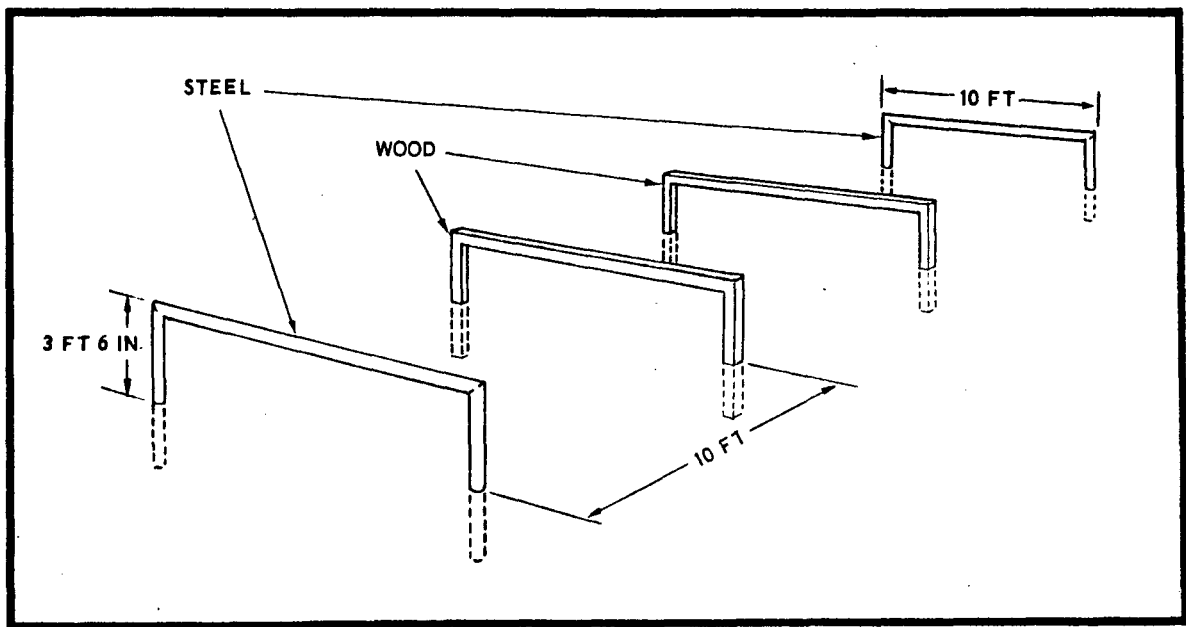
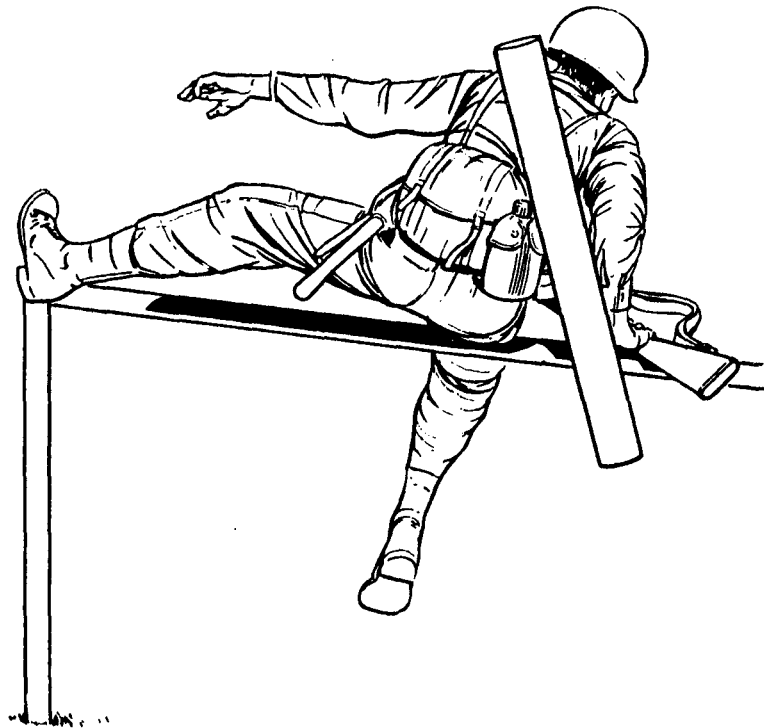


Figure A-18. High Rail Vault

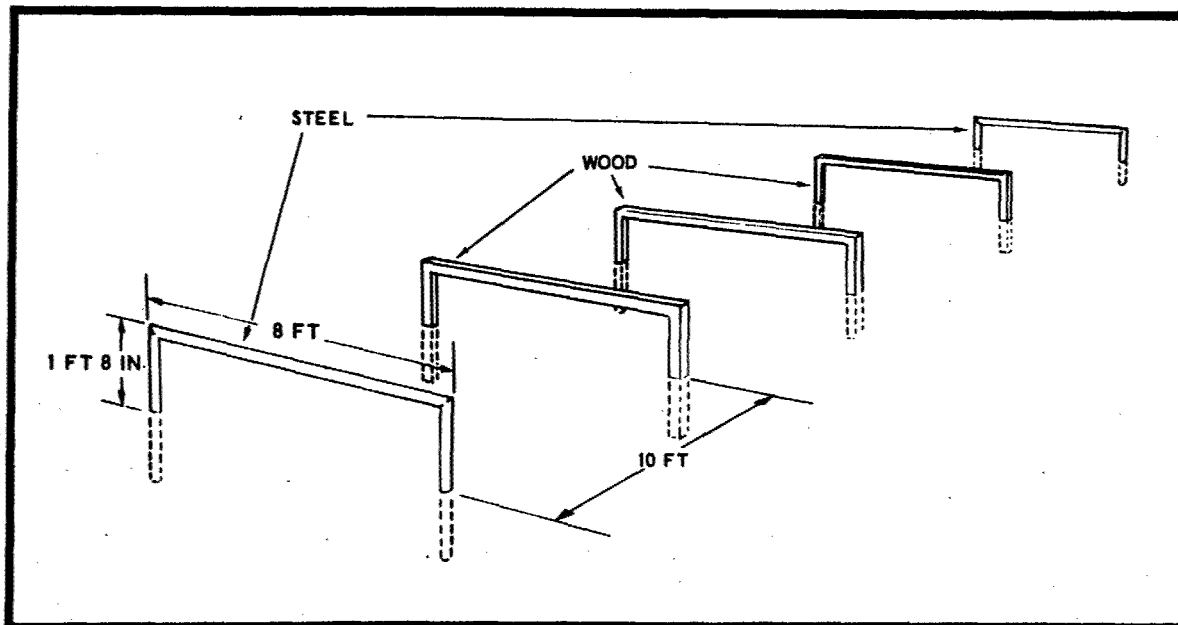
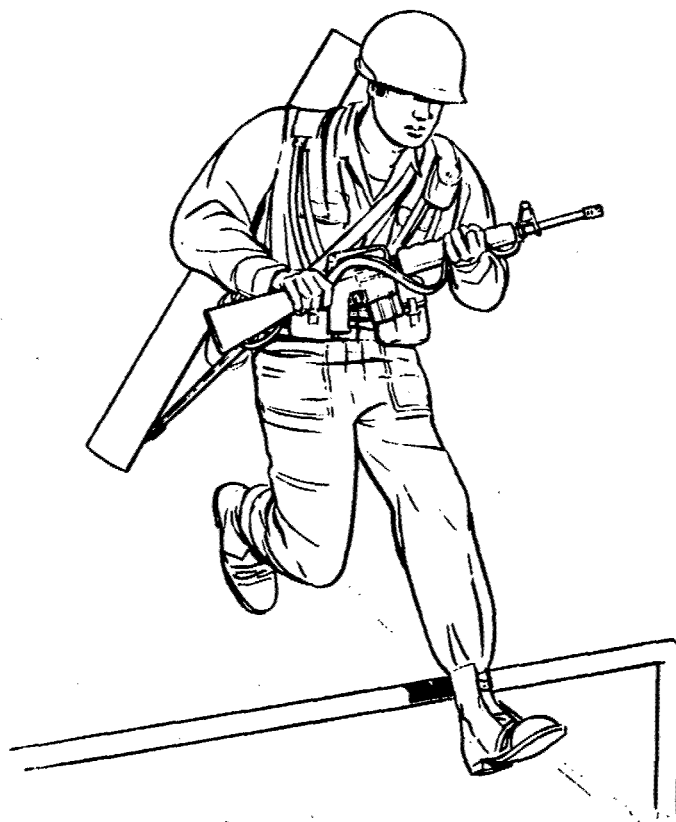


Figure A-19. Low Rail

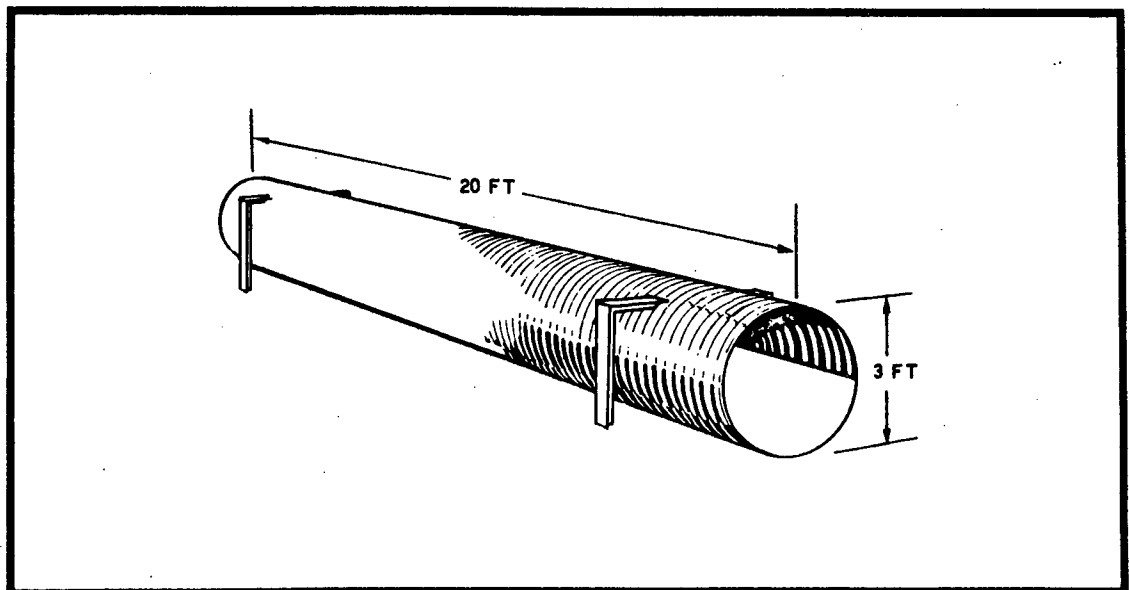
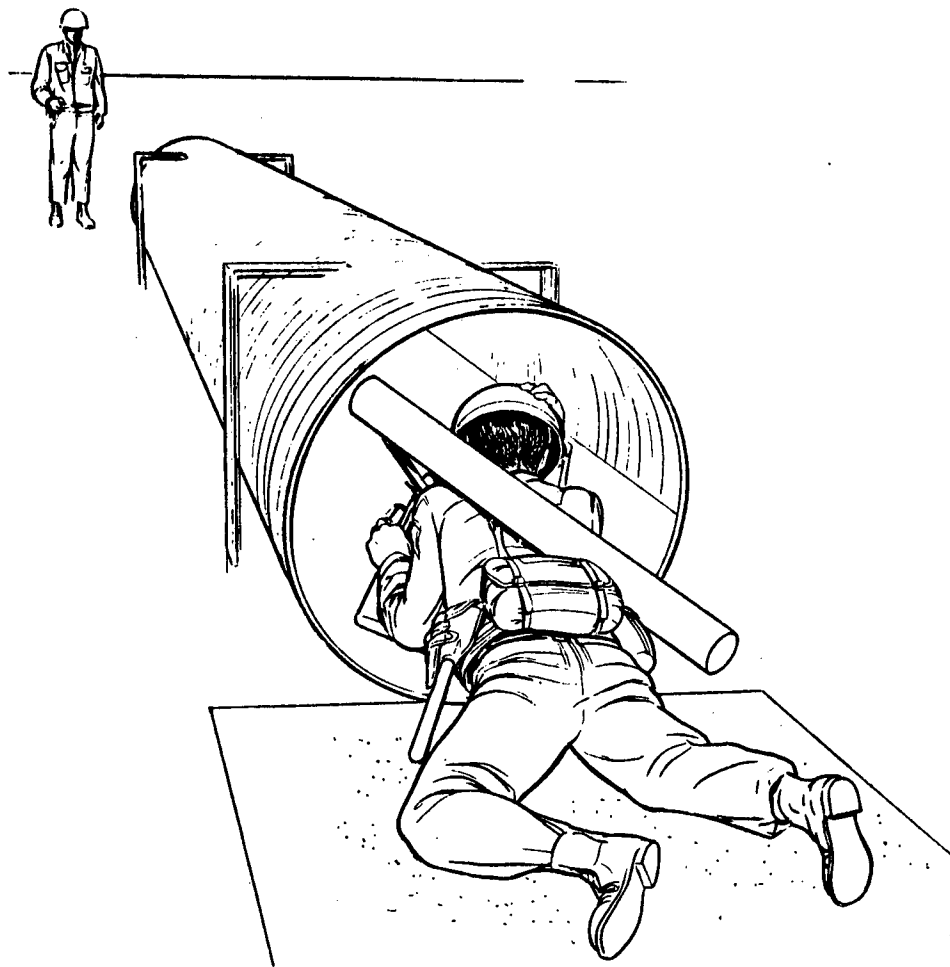


Figure A-20. Pipe Crawl

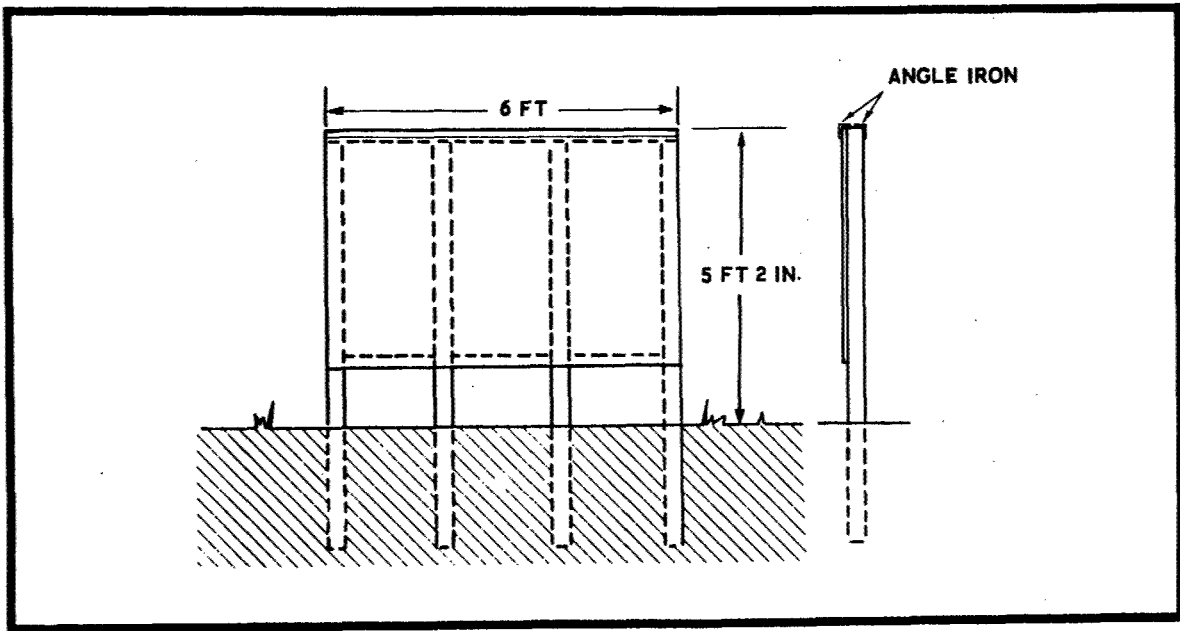


Figure A-21. Wall

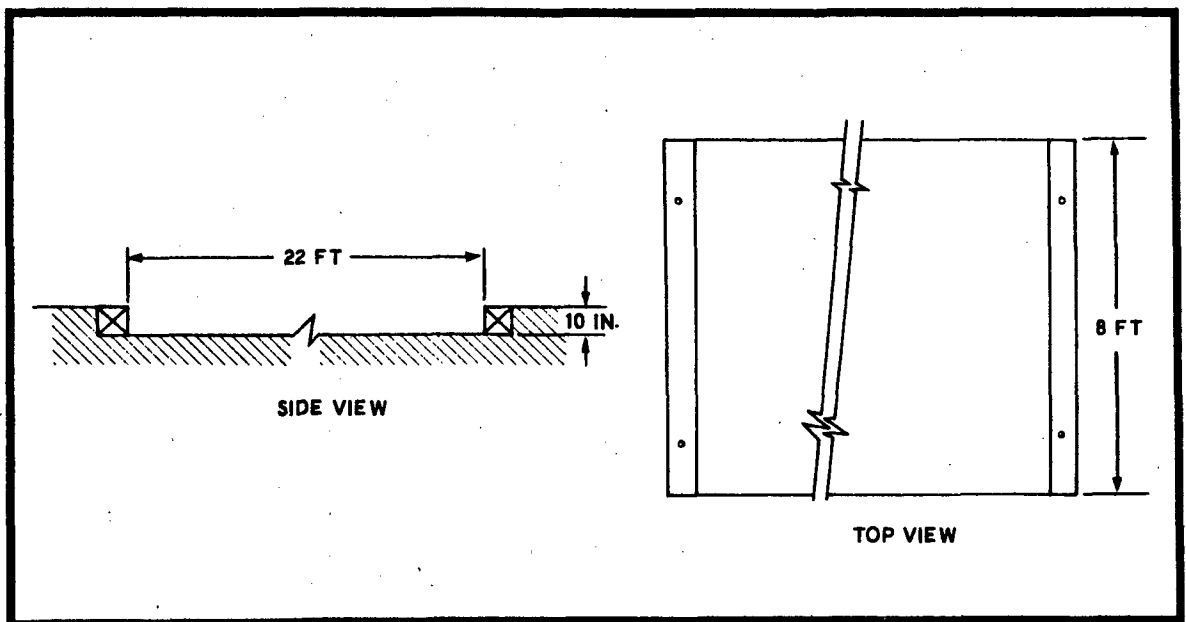
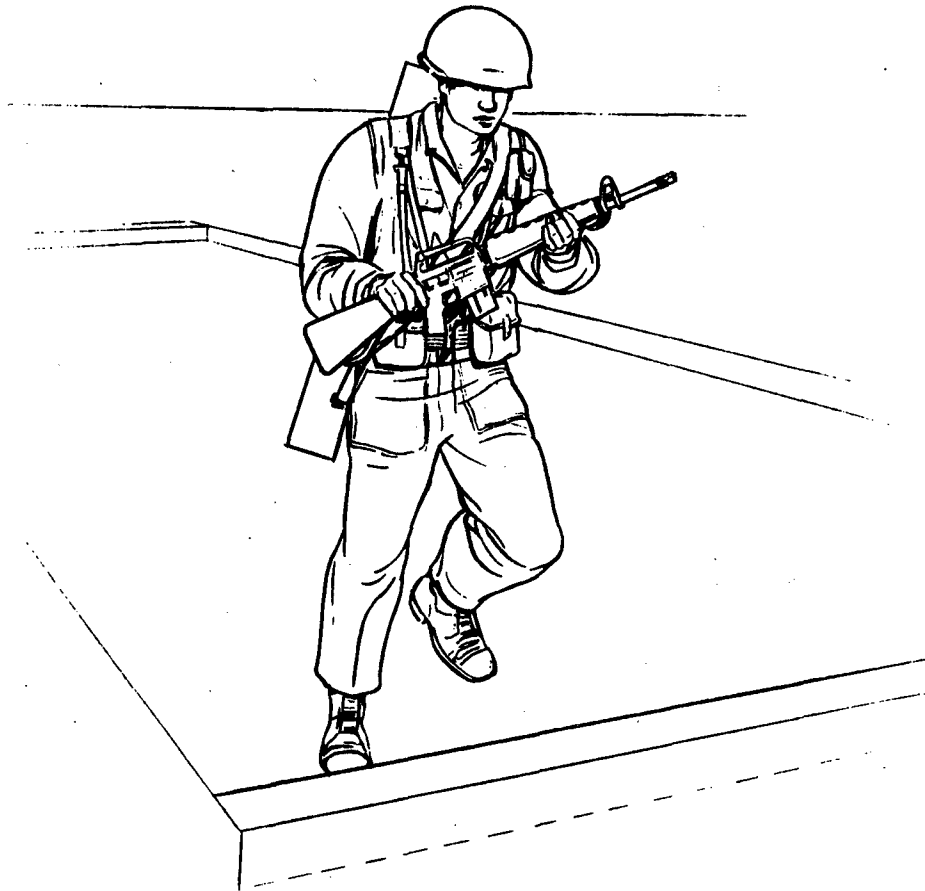


Figure A-22. Curbs

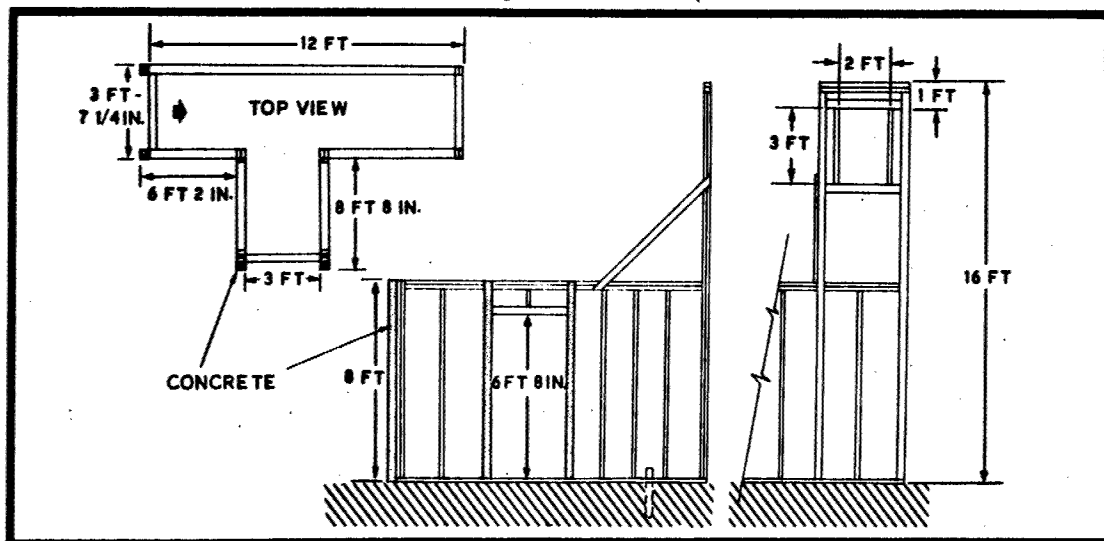
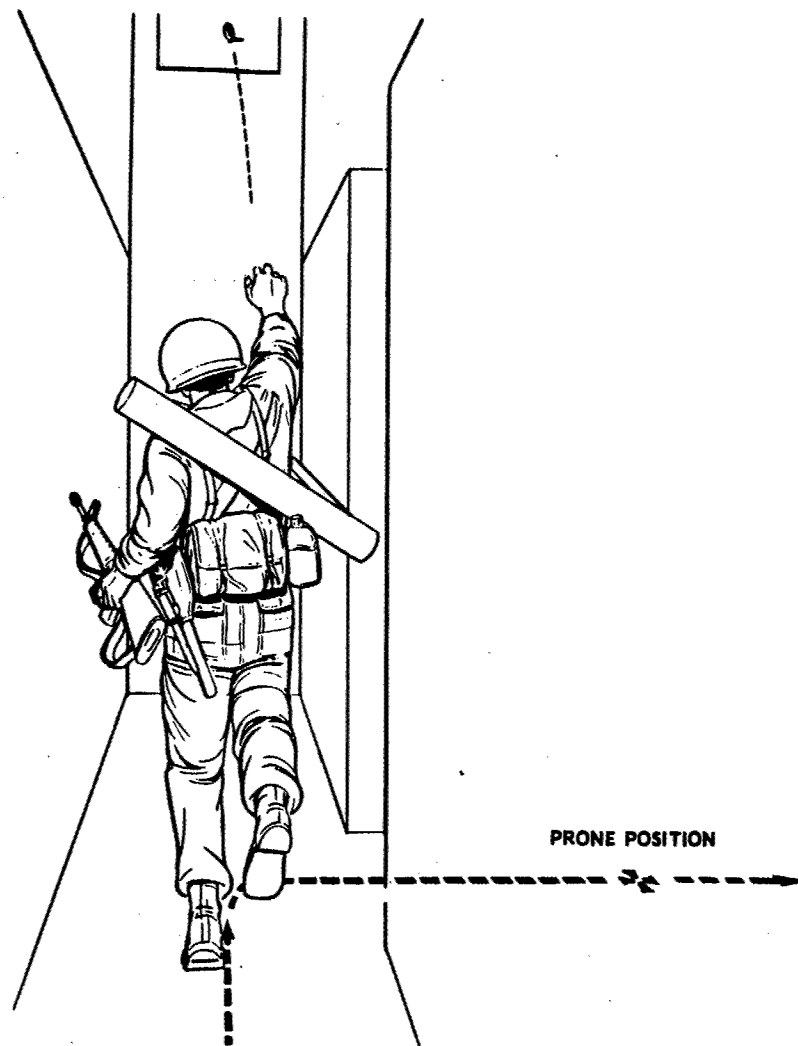


Figure A-23. Alley Grenade Throw

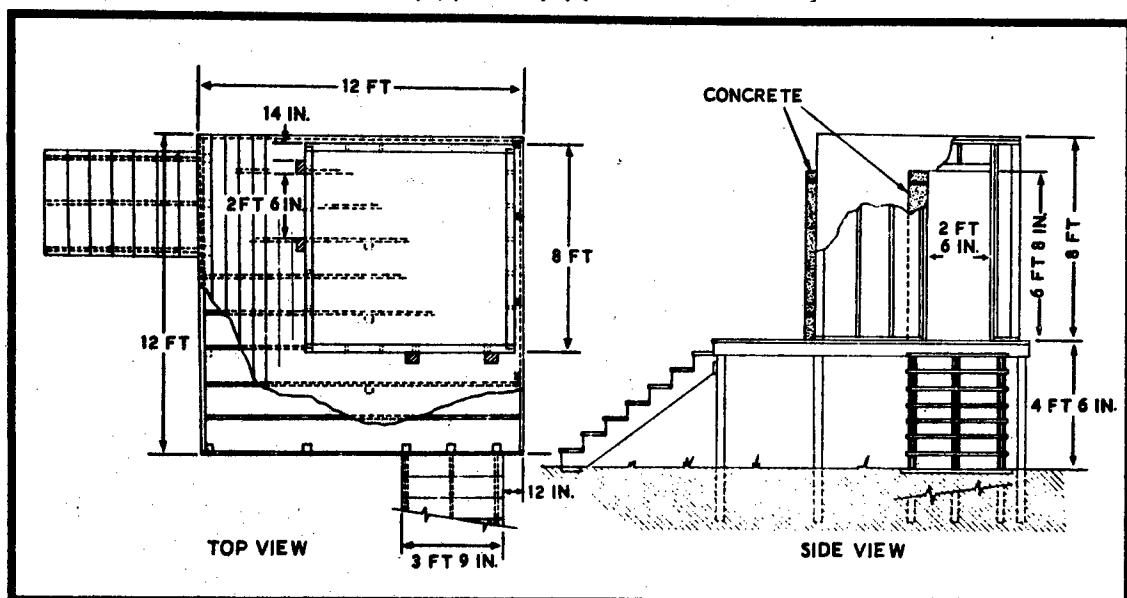
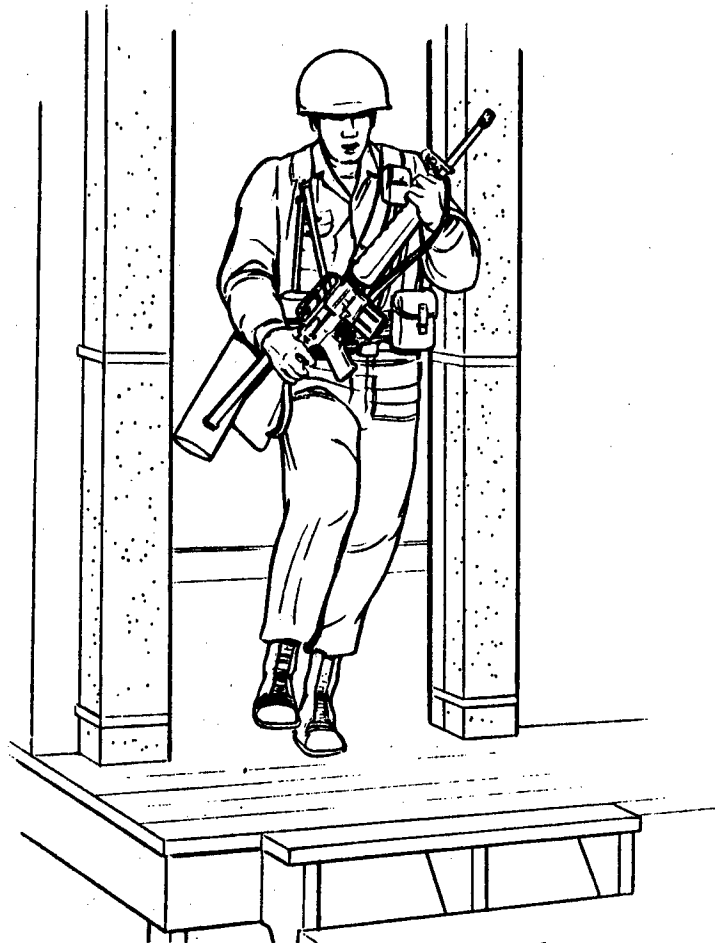


Figure A-24. Stairs and Doorways

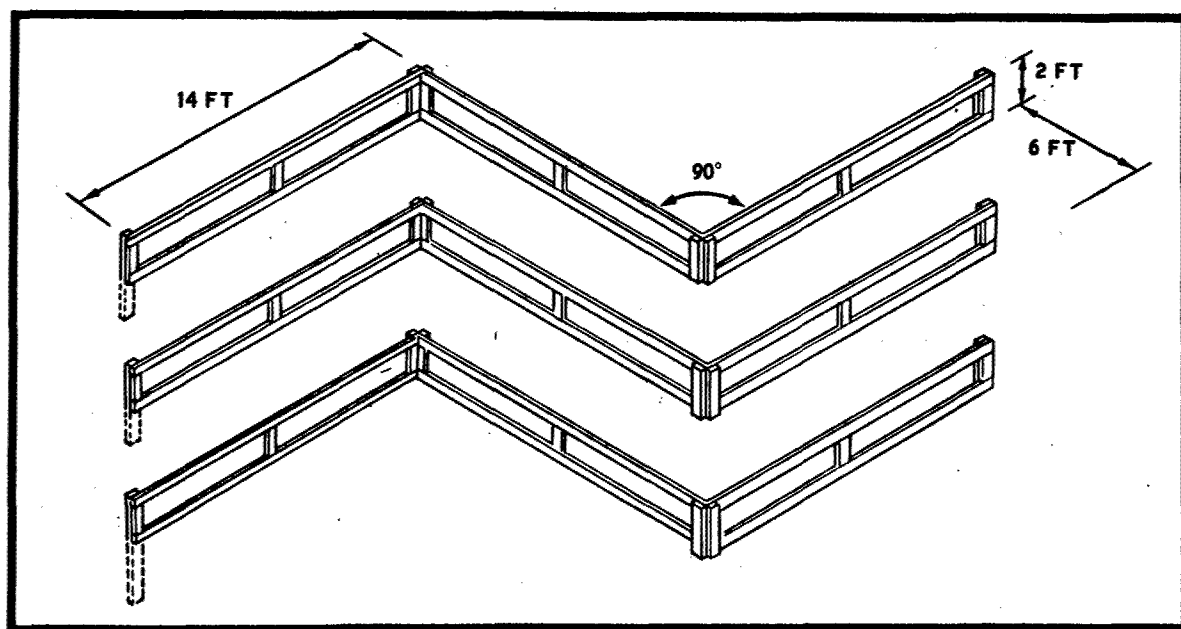
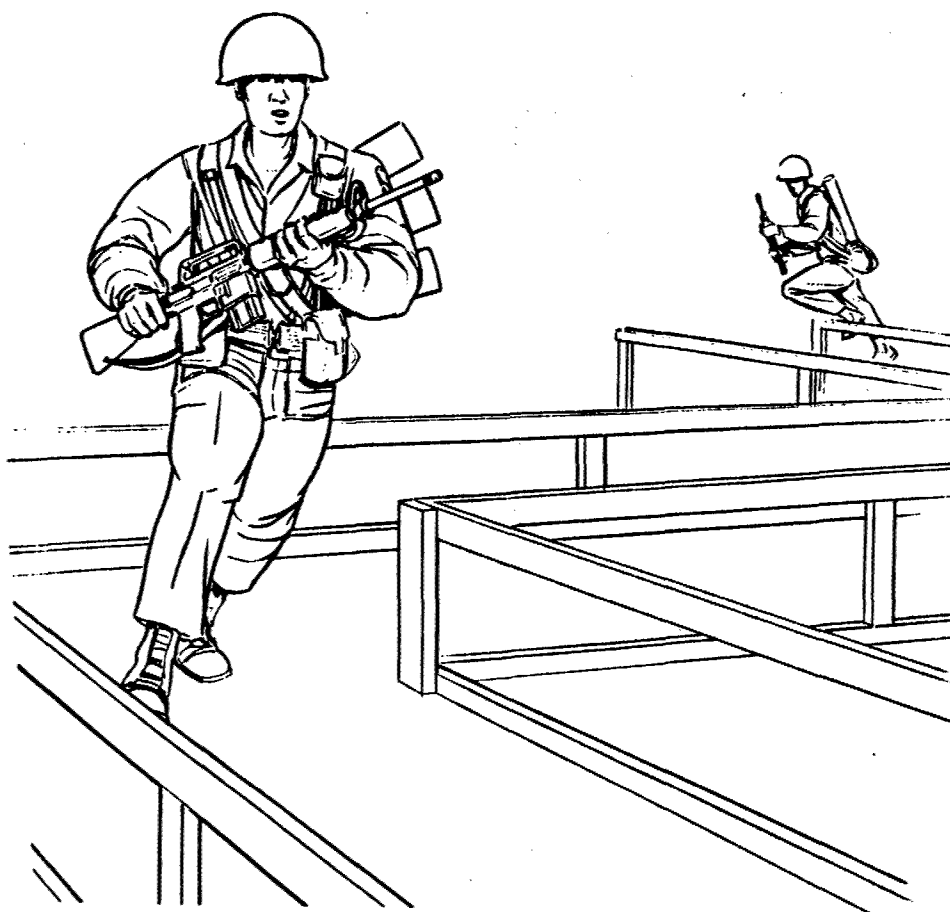


Figure A-25. 90° Passways

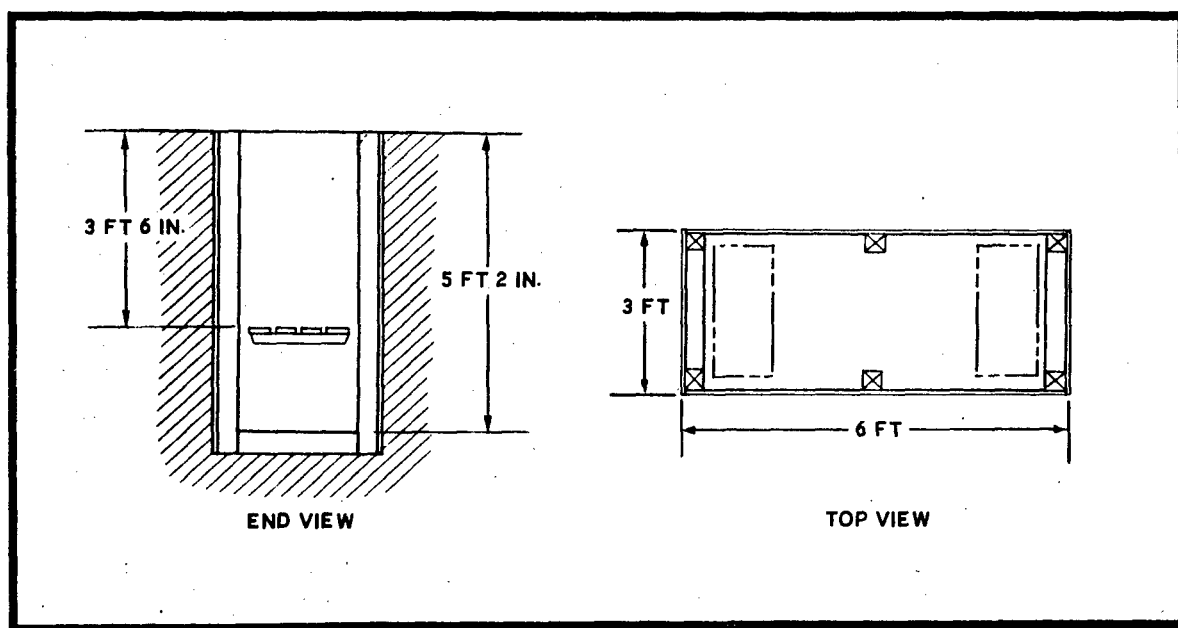
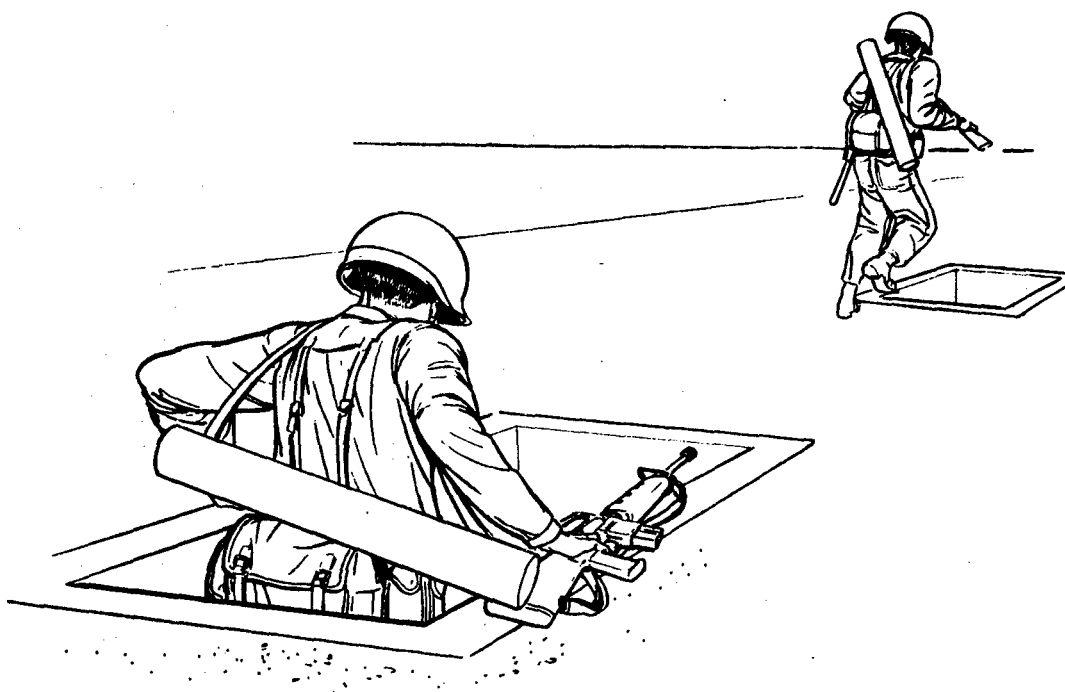


Figure A-26. Two-Man Foxhole

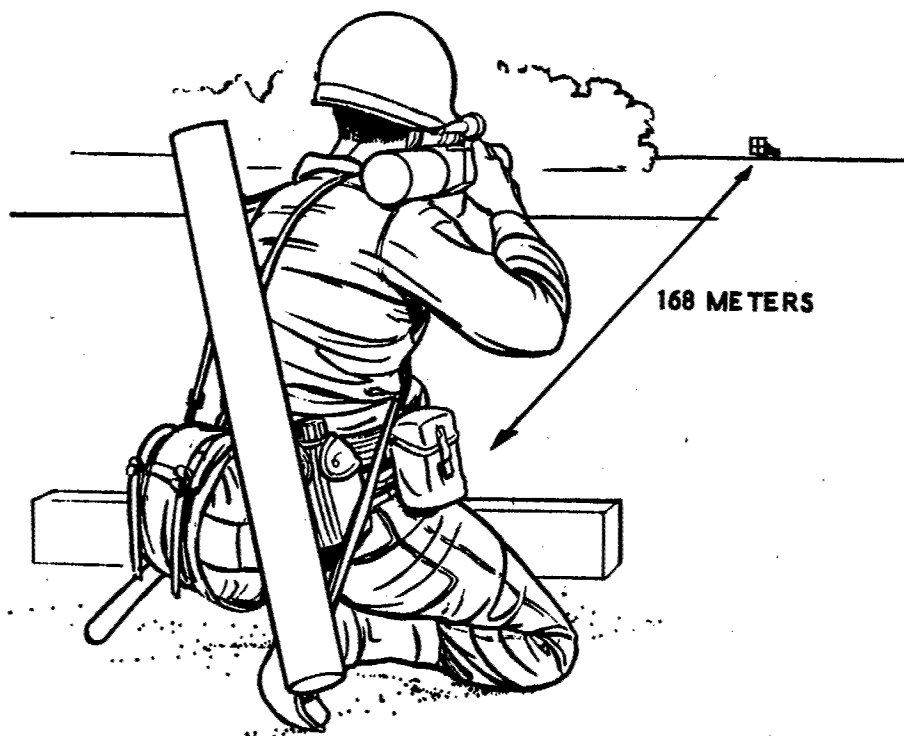


Figure A-27. Antitank Aiming.

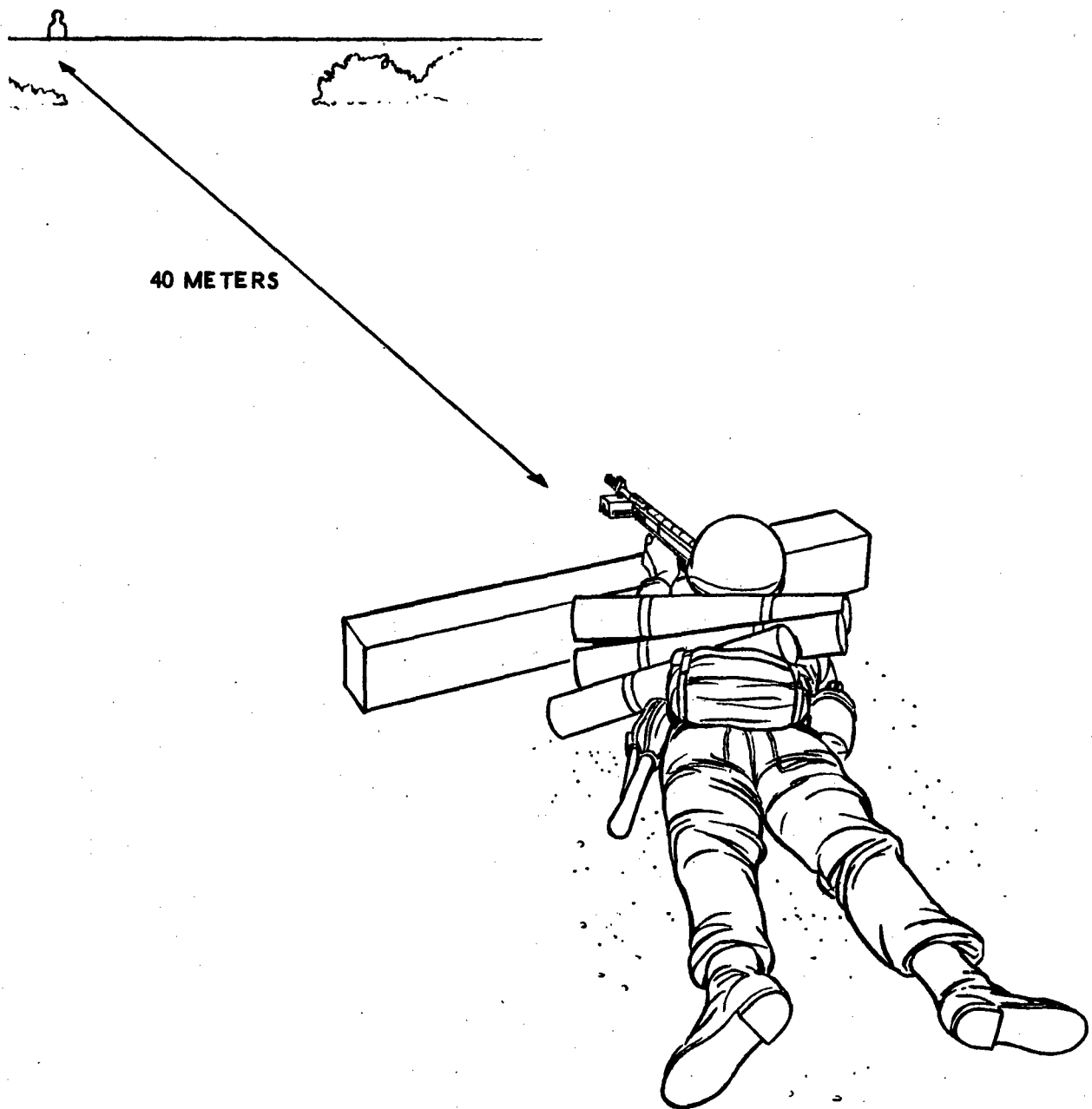


Figure A-28. Rifle Aiming

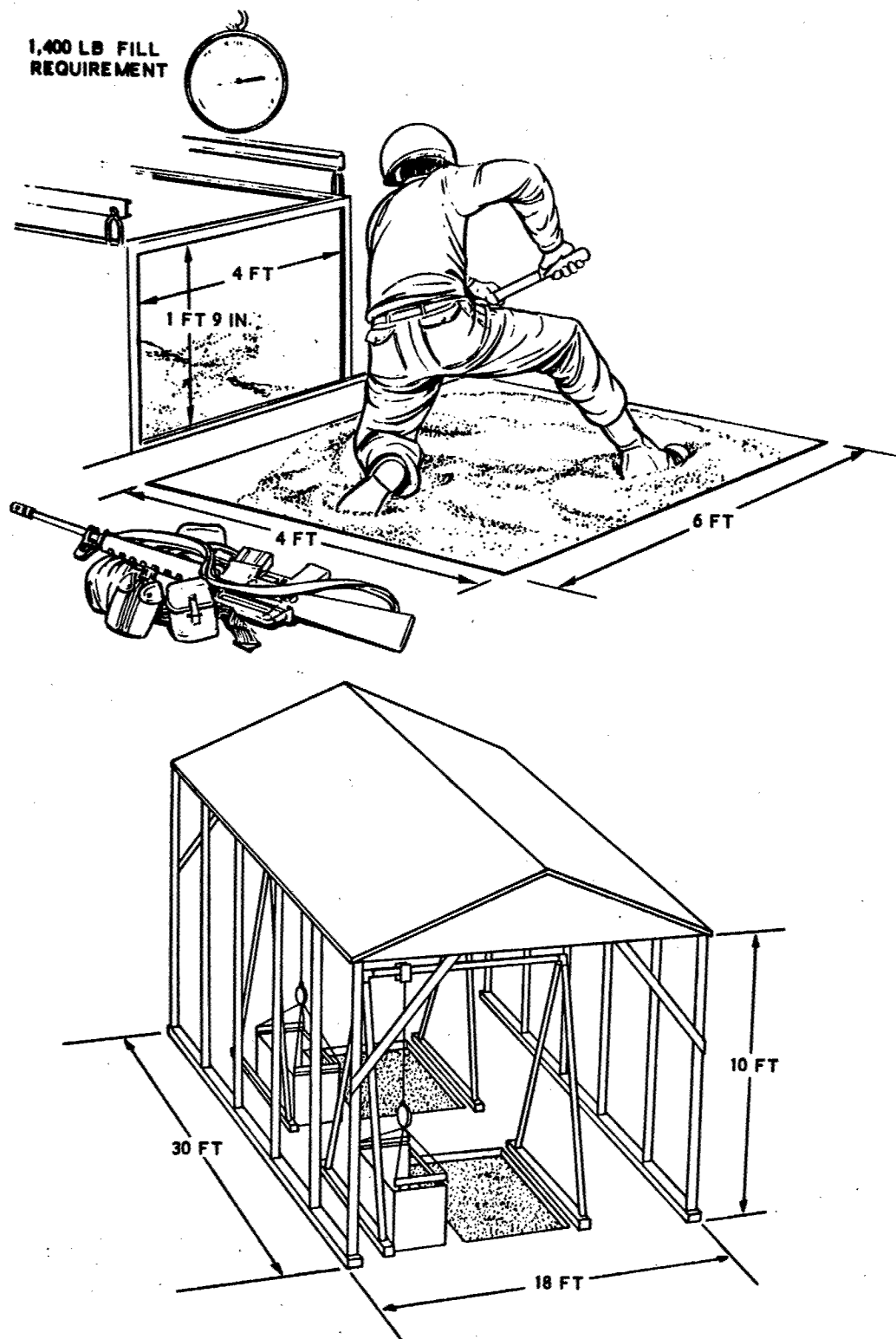


Figure A-29. Digging Foxhole

APPENDIX B

SCENARIOS PROVIDED BY THE CDC INFANTRY AGENCY

TRUE COPY



DEPARTMENT OF THE ARMY Mr. Brown/bh/255-1016
UNITED STATES ARMY COMBAT DEVELOPMENTS COMMAND
INFANTRY AGENCY
FORT BENNING, GEORGIA 31905

CDCIN-CM

19 May 1972

SUBJECT: LAW-Human Interface

Commanding Officer
US Army Research and Development Center
ATTN: AMXRD-HEL (Mr. Torre)
Aberdeen Proving Ground, Maryland 21005

1. Reference is made to visit by Mr. J. P. Torre and Mr. D. J. Giordano to the Infantry Agency on 14 March 1972.
2. Two responses are required in addition to the matters resolved at the conference. These are: first, two tactical scenarios are at Inclosure 1 within which most of quantitative aspects of LAW portability and handling can be measured; and secondly, a list of individual equipment is at Inclosure 2 which is to be worn and carried by individuals on the above tactical operations.
3. Some typical requirements are listed for the flow of the scenario to proceed from a starting point to an objective. Additional requirements may be added to these scenarios if additional measurements are to be made. Variable terrain should be utilized to provide for the world-wide deployment capability of the Light Antitank/Assault Weapon. The dismounted attack scenario provides for extremely rugged terrain, generally impassable for tracked vehicles.
4. These scenarios do not provide special environments such as attack of beaches, river lines, built up areas, or heavily fortified positions. These are not day-to-day operations and special measures can be taken to offset most of the problems peculiar to these special operations.

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CDCIN-CM

SUBJECT: LAW-Human Interface

5. The Infantry Agency stands ready to provide additional consultation and assistance to insure a valid evaluation of the Human Interface measurements for a LAW type weapon.

FOR THE COMMANDER:

2 Incl
as

/s/
WALKER D. WILLIAMS
Captain, Infantry
Adjutant

MOUNTED MOVEMENT W/DISMOUNTED ATTACK

1. General Doctrinal Techniques.

a. All-round security in the Offense. While moving in column, continuous protection to the flanks against enemy armor must be provided. Although the M72 supplements other organic antitank weapons, it provides the primary means of antitank protection for the rifle squad and other units or installations not having organic antitank weapons.

b. Light antitank weapons (M72) should be readily available to influence the action where necessary. Due to their relatively short range, they should be interspersed throughout the maneuver element. As the weapon is designed to be employed by an individual, the firer must look to the rear before firing to assure backblast clearance. Light AT weapons are employed primarily against armored vehicles; they may also be employed against light vehicles, bunkers, pillboxes, or other crew-served weapons positions. They are particularly effective against built up areas, fortified positions, or strong enemy defenses.

c. Antitank weapons in the conduct of the defense during the reorganization phase of the attack open fire on appropriate targets when the enemy comes within effective range. Every effort is made to separate the tanks and enemy infantry. If the Infantry attack is repelled, but the tanks continue to advance, selected personnel should be directed to place small arms fire at tank periscopes and exposed crewmen and use light antitank weapons (LAW). Individual riflemen armed with LAW may, on order, engage close enemy armor. LAW should be issued to personnel in such a manner as to be positioned laterally and in depth to cover the most likely avenues of armored approach. Lateral dispersion is necessary to increase the probability of obtaining oblique fire on enemy armor. Due to its one-shot capability, more than one LAW should normally be assigned to those individuals designated to fire the weapon. Since riflemen may be issued the LAW to fire from their normal fighting positions, consideration must be given to the clearance of backblast areas in conjunction with the construction of positions. Although the LAW is employed primarily against armor, it may also be employed against grouped, defending or attacking personnel.

2. Scenario — Mounted Movement to Contact with a Dismounted Attack.

a. General Situation — Your company, presently in reserve, has been given the mission of moving through the companies on the FEBA to seize hill _____. The enemy appears to be defending with one tank platoon in your company's sector from well-prepared bunkered positions.

b. Initial Situation — You are squad leader — 1st squad and have just been told by your platoon leader that your squad, as part of a larger force in the vicinity of _____ Company's rear at coordinates _____, mounted in APCs to complete preparations to seize hill _____. You were also told to draw supplies (ammo and chow) for three days and that the basic load of antitank weapon ammunition be doubled for antitank and bunker assault. The platoon leader has informed you that he is going forward to make his recon with the C.O. and will meet you in the assembly area at _____ hrs. The FEBA will be crossed at _____ hrs. LD is LC.

c. Second Situation — Your squad is in the assembly area with all preparations completed. The Platoon leader has completed his reconnaissance and is now providing a more detailed final briefing to the squad leaders. You are told that your company is the secondary attack due to the terrain and has 2nd priority of artillery fires. A 20 minute non-nuclear preparation of hill _____ will commence at H + 15, with H being the time of FEBA crossing. You have also been informed that the reconnaissance revealed that the APCs would not be able to accompany the attacking force all the way to the objective because of terrain restrictions. You have been instructed to dismount your troops at PL BLUE, continue the attack dismounted, seize the objective and prepare to continue the attack, on order. The APCs will assemble vicinity coordinates _____, behind the objective on order, in preparation for a continuance of the attack. Your squad will be the left flank unit of the attacking force.

d. Third Situation — The attack is under way. You have just passed the COPL and begin receiving heavy machine gun fire from what appears to be a semi-fortified bunker on your squad's left front.

First Requirement — APC will halt for fire missions.

e. Fourth Situation — As bunker is engaged and destroyed, a lightly armored enemy vehicle is spotted moving away from the bunker toward the general direction of the objective.

Second Requirement — One LAW gunner will engage the enemy vehicle from the hatch of the APC with minimum exposure time. (Prepare LAW for firing prior to becoming exposed).

f. Fifth Situation — As your squad arrives at PL BLUE, it comes under light small arms and AT fire. You are ordered to dismount your troops to engage the enemy and move the APCs out of the area.

Third Requirement — Prior to dismounting, one LAW gunner will engage a stationary target from the APC. Another LAW gunner will dismount, take up a firing position as back up for the LAW gunner firing from the APC.

Fourth Requirement — The squad, upon completing the engagement at PL BLUE, proceeds toward the objective through "difficult terrain," dismounted.

g. Sixth Situation — As the squad emerges from the difficult terrain, mortar fire begins falling and a stationary target appears near the objective.

Fifth Requirement — The squad moves quickly through the mortar fire. (Dodge and run from cover to cover).

Sixth Requirement — One LAW man engages a stationary tank target at mid range while the remainder of the squad continues the advance, crosses the FCL, and builds up fire superiority.

h. Seventh Situation — As the squad approaches the objective, they suddenly receive a large volume of fire from what appears to be a fortified bunker. The squad is momentarily pinned down.

Seventh Requirement — One LAW gunner engages the bunker by crawling to a point which would enhance his view of the bunker.

i. Eighth Situation. After the bunker is destroyed, the final assault is launched; enemy fire from the objective area becomes weak and sporadic. The objective is seized and all units consolidate on the objective. The APC rejoin their unit on the objective and resupply is effected.

j. Ninth Situation – In order to properly consolidate objective it is necessary to establish local security. The company commander has ordered a series of hilltop positions approximately 500 meters forward of the objective be occupied by squad size units. You are ordered to move your squad to hill___ and prepare hasty defensive positions to complete your combat outpost role. The enemy threat continues to leave a tank capability for use in counterattack on your position. Riflemen in the squad will each carry 2 LAW to supplement the MAW assigned to the squad for this mission.

k. Tenth Situation – You have moved your squad and have prepared hasty positions on hill___. One-man foxholes for riflemen and an antitank weapon emplacement for the MAW. Two tanks and approximately 1 squad of infantry suddenly appear from a tree line 250 meters from the left flank, moving in the main position. The MAW engages one tank.

Eighth Requirement – One LAW gunner engages the nearest tank from his individual foxhole with three LAW. Individual fires multiple shots preferably preparing the weapon for firing under cover of the foxhole.

SPECIALIZED ACTIONS – RAID

1. General Doctrinal Techniques.

a. Man-portable antitank weapons lend themselves to raids on communication centers, tank parks, ammunition and supply dumps, and command posts, as this type of operation is designed to accomplish a specific task or to create psychological unrest in the enemy's rear areas. Within their range, they allow a patrol to stand off from the objective, destroy it, and move out before the enemy has a chance to react. On deep penetrations against large targets, more than one LAW per man should be carried. Packboards or rucksacks enable a small patrol to carry enough LAW to destroy a relatively large target.

b. Security elements, carrying automatic weapons, provide a good balance of firepower for small size patrols.

c. At the objective, the patrol leader must insure that weapons are employed within their capabilities and that the mission is not sacrificed due to haste or carelessness. Since it is discarded as soon as it is fired, the LAW is a good patrol weapon and readily supports the hit-run type tactic of the raid.

2. Scenario – Heliborne operation to conduct a RAID.

a. General Situation – Your company has just been given the mission of conducting a raid on a large enemy supply complex which includes an ammunition storage area in the vicinity of coordinates _____. Because of the distance involved (25 miles) and the urgency of accomplishing the mission at a specific time, your company has been allocated two UH-1D helicopters to be utilized in conjunction with the raid. (Training in entering and exiting helicopters should be conducted).

b. Initial Situation – You have been designated as the patrol leader for the raid. You have been informed by the S-3 that the mission of destroying the supply complex is to be a surprise attack in an effort to demoralize the enemy. The success of the mission will create a psychological advantage for an all out attack which will begin exactly one-half hour after the destruction of the supply complex. Current intelligence indicates that the complex is not too heavily fortified, particularly during the time when the enemy's resupply vehicles conduct resupply operations. You have been told to hit the supply complex at ____ hrs. Since the resupply convoy will have just returned from their journey, these should also be destroyed during the raid. From your discussions with the S-2 and S-3 and a brief map reconnaissance, you determine that the 10-man patrol you have selected will utilize the two helicopters to carry the patrol to within five miles of the supply complex. Because of other missions for the two helicopters, the S-3 has directed that your patrol infiltrate back to friendly lines upon completion of the mission. You direct your patrol to carry at least three days of rations and water in addition to their basic load of small arms ammunition. Five men in the patrol will carry four LAW each, while the other four carry one LAW each plus their automatic weapon. Your patrol will assemble at the PZ at ____ hrs. You have received the checkpoints, SØ1, call signs, etc.

c. Second Situation – Your patrol is at the PZ and last minute checks are being made. Two helicopters arrive at ___ hrs. The S-2 and S-3 give the pilots a thorough briefing on the operation.

First Requirement – Patrol members board the helicopters with their gear and weapons. Patrol leader briefs pilot on mission, route to the LZ and the LZ.

d. Third Situation – The patrol arrives at the LZ as planned. The troops are prepared to unload quickly as the helicopter will not touch down. An assembly point must be selected at a covered position in proximity to the LZ.

Second Requirement – The patrol unloads from the helicopters quickly and rushes to clear the LZ by running the patrol toward a predetermined assembly point. The patrol then begins its movement toward the supply complex with individual weapons at the ready.

e. Fourth Situation – While advancing toward the enemy supply complex, the patrol hears and eventually observes an enemy patrol moving in their direction.

Third Requirement – The patrol, not wanting to make contact in order to preserve the element of surprise, takes evasive action.

f. Fifth Situation – The evasive tactic was successful and the patrol continued its mission. The patrol emerges from dense foliage and sees the road they are to cross. Suddenly, they hear a large number of vehicles approaching their position near the road.

Fourth Requirement – Again, the patrol takes evasive action, conceals itself and determines that the vehicles were the enemy supply trucks heading away from the supply complex.

g. Sixth Situation – The patrol reaches the enemy supply complex near dusk. The patrol leader sets up his security and then, taking along a team leader, conducts a detailed reconnaissance of the complex. At the same time the patrol leader begins his selection of tentative firing positions and so informs the team leader. Upon completion of the reconnaissance, the patrol leader rejoins his patrol and proceeds to lay out his plan to the patrol and assign targets to all patrol members.

Fifth Requirement – The patrol moves out under cover of darkness to assume its firing positions. During this movement the sound of a truck convoy can be heard entering the compound, forcing the personnel to crawl the last 50 feet to attack positions.

Sixth Requirement – At a predetermined time and signal, eight LAW gunners each fire three rounds at their assigned targets.

h. Seventh Situation – The supply complex was put into chaos; surprise was achieved; numerous trucks were destroyed, others damaged, and communication lines were down. The raid was a success! The patrol began their long movement back, initially moving rapidly into an assembly area followed by long, cautious infiltration action to friendly lines.

APRIL 1972

1. Temperate Zone Fighting and Existence Load Items.

I. Fighting Load

Approximate Weight
(Lbs.)

a. Clothing:

(1) Helmet w/liner	3.00
(2) Trousers and jacket (Jungle) (med)	3.00
(3) Underwear (summer) and socks	.60
(4) Boots (leather DMS)	3.40
(5) Poncho	<u>1.50</u>

Total 11.50

b. Equipment:

(1) Rifle w/sling (M-16)	7.20
(2) 100 Round ammo w/5 (20 rd mag)	3.50
(3) Ammunition pouches (2) (20 rd mag)	1.50
(4) Canteen (filled) w/ cup and carrier (2)	6.10
(5) Belt, M-14 w/first aid pouch and packet, and suspenders (all cotton)	2.00
(6) Entrenching tool w/carrier (folding)	2.20
(7) Bayonet w/scabbard	<u>1.10</u>

Total 23.60

c. Rations:

(1) Meal (1) (MCI)	<u>1.80</u>
--------------------	-------------

Total Weight (Fighting Load) 36.90

II. Existence Load (abbreviated)

a. Sleeping bag w/carrier and pneumatic mattress	12.90
b. Pack (Jungle) w/underwear, socks, toothbrush, etc.	4.20
c. 3-day ration (9 MCI)	<u>15.90</u>

Total Weight (Existence Load) 33.00

2. It is important to note that the listings above are by no means all inclusive and in fact include almost none of the organizational equipment common to the infantry company, e.g., compass, binoculars, tentage, panel markers, claymore mines, hand grenades, extra 81mm mortar ammunition, extra MG ammunition, smoke grenades, etc.

3. The current armored vest weighs 8.5 lbs and may be worn on assault type operations. (It is not recommended for either of these operations).

4. The fighting load (IA, B, C) should be carried on both these operations in addition to the LAW. Additional meals are necessary for the RAID.

APPENDIX C

TESTS CONDUCTED BY THE U. S. ARMY INFANTRY SCHOOL

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APPENDIX C
TRIP REPORT

24 July 1972

SUBMITTED BY: Captain Charles Matts

SUBJECT: Advanced LAW Portability

PLACE: Fort Benning, Ga., and Fort Bragg, N. C.

1. On 17-19 July 1972, I visited the USAIS, Weapons Dept. and Airborne Dept. at Fort Benning Ga., for the purpose of briefing them and running a series of tests on the Qualitative Aspects of Portability.

2. The two principal officers contacted were LTC Byerly, Weapons Dept., and CPT Gavel, Airborne Dept., USAIS.

3. Upon receiving the LAW Portability briefing, LTC Byerly had the following comments:

a. That the weight of the system be secondary as opposed to the system accomplishing the mission.

b. That the back blast be taken into consideration when firing from MICV.

c. That actual parachute jumping with equipment be accomplished.

d. That a 10-lb. and 12-lb. system be used in the portability study.

4. The following is the sequence of events which took place at the Airborne Dept., USAIS, Fort Benning:

a. Still photos were taken of individual weapons container empty.

b. Still photos were taken of each of the following systems in the weapons container:

No. 1	2 ea	24"/8 lb	S	Sys
No. 2	2 ea	31"/8 lb	S	Sys
No. 3	1 ea	43"/8 lb	B	Sys

Trip Report
SUBJECT: Advanced LAW Portability

24 July 1972

c. Motion pictures were taken of a parachutist jumping from the 34-foot mock tower with systems in the weapons container and PA&E bag in the following sequence:

No. 1	1 ea	43/8 lb	B	MT
No. 2	1 ea	37/16 lb	S	MT
No. 3	2 ea	31/8 lb	S	MT
No. 4	2 ea	25/8 lb	S	MT
No. 5	1 ea	31/8 lb	B	MT
No. 6	1 ea	25/8 lb	B	MT
No. 7	5 sys	40 lb	B	PAE Bag MT
No. 8	5 sys	40 lb	S	PAE Bag MT

d. There were no difficulties encountered in jumping from the 34-foot tower.

5. All systems were placed in the weapons container and a parachutist performed parachute landing falls from the Swing Landing Trainer.

6. The only problem noted was the parachutist could not do a proper P.L.F. with the 43-inch system in the weapons container.

7. There were no difficulties noted while dropping from the 250-foot tower with the systems. A drop with the 43" system was not attempted.

8. On 20 and 21 July I visited the 82d Airborne Division at Fort Bragg to discuss the aspects of portability of the present LAW.

9. The principal officer contacted was CPT Buck, Asst. S-3, 1st Battalion 504th Airborne Infantry.

10. I interviewed 26 individuals, all of whom had had some experience with the LAW. The following are the results of the interviews:

Q. What method does your unit use to carry the LAW?

All individuals stated that they attach them to the top of the rucksack.

Q. If LBE was used rather than the rucksack, how would you prefer to carry the LAW?

(1) Nineteen stated they would carry it bandolier style.

(2) Seven stated they would carry it at sling arms.

Q. How many LAWs are carried by your squad?

In all cases, two were carried by each squad.

Q. If you were squad leader, would you consider carrying a system that was 43 inches long and weighed 24 pounds?

Twenty-five individuals answered no. One individual stated if it was effective against armor, yes.

11. Recommendations/Comments:

a. That the 43-inch system not be used if actual parachuting is done.

b. That the equipment bag be used to jump 25- and 31-inch systems.

c. That the prototype of the systems being considered be jumped by using units.

/s/
CHARLES MATTS
CPT, INF

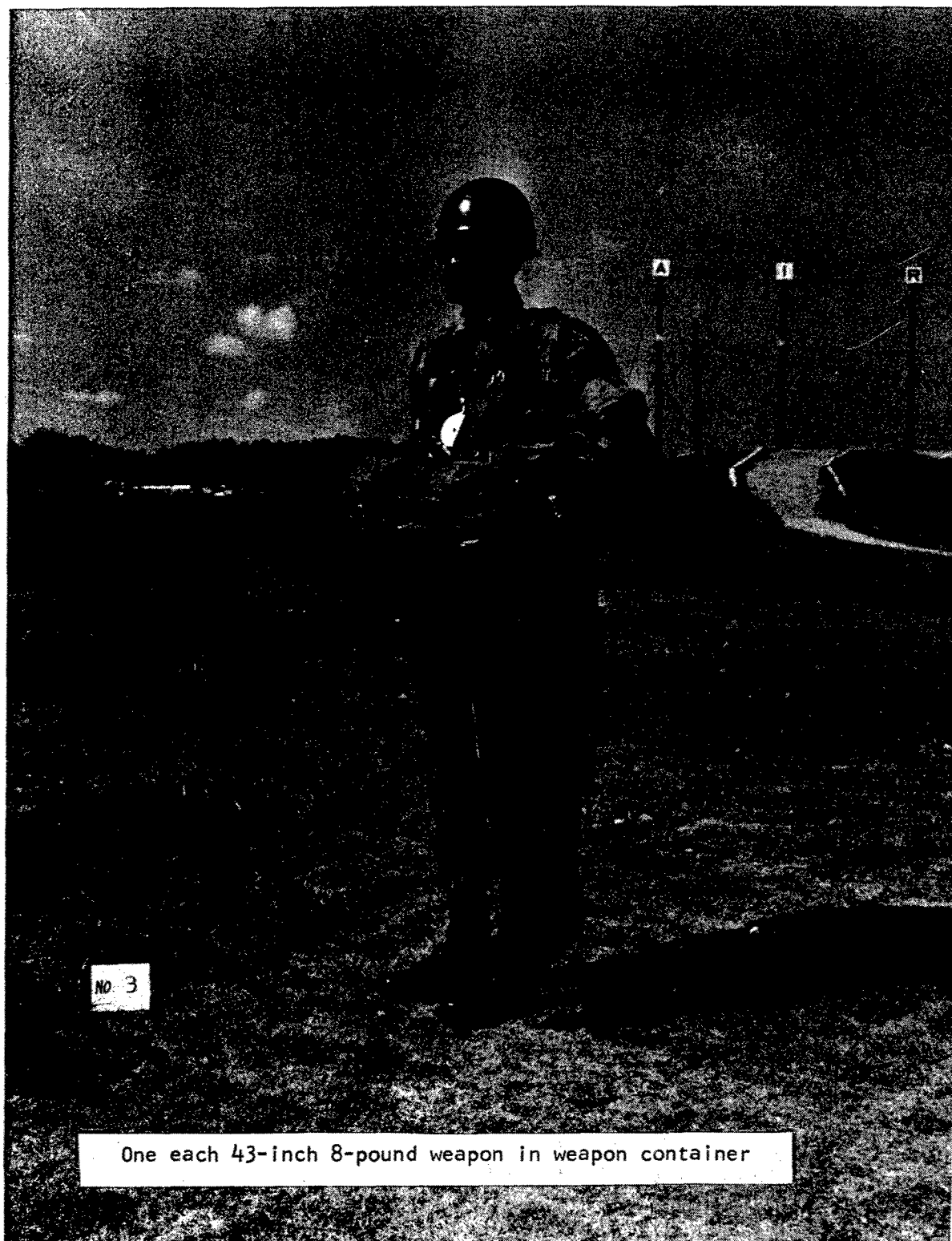


Fig. 1C. Airborne soldier with jump equipment.

APPENDIX D

QUESTIONNAIRE FOR THE PORTABILITY STUDY

PORTABILITY STUDY

1. In general how would you rate the test weapon that you carried today with respect to its portability (ease of carry)? (circle one)

very neutral very

(EASY to carry) 1 2 3 4 5 (HARD to carry)

 somewhat somewhat

2. Rate the weapon you carried today with respect to the following characteristics: (circle one number for each row)

		very	somewhat	neutral	somewhat	very	
a	COMPACT	1	2	3	4	5	BULKY
b	HEAVY	1	2	3	4	5	LIGHT
c	SHORT	1	2	3	4	5	LONG
d	COMFORTABLE	1	2	3	4	5	UNCOMFORTABLE
e	STABLE	1	2	3	4	5	WOBBLY
f	LARGE	1	2	3	4	5	SMALL
g	SLIPS	1	2	3	4	5	CLINGS
h	LOOSE	1	2	3	4	5	TIGHT
i	MANAGEABLE	1	2	3	4	5	UNMANAGEABLE
j	BURDENSOME	1	2	3	4	5	EFFORTLESS

3. Did any of the following characteristics about the weapon you carried today cause you difficulty? (check any that apply)

 weight length position of carry

4. Which obstacle in the portability course gave you the most difficulty because of having to carry the test weapon? _____

5. What was it about the test weapon that caused you to have the difficulty with the obstacle in question number 4? _____

6. Which obstacle in the portability course gave you the least difficulty?

7. While carrying the test weapon today did the: (answer all questions)

yes - no

- a _____ strap cut into your shoulder?
- b _____ weapon get tangled (if yes, what part)? _____
- c _____ weapon fall off your shoulder?
- d _____ weapon flop around and bump against parts of your body (if yes, what parts)? _____
- e _____ weapon prevent free movement of parts of your body (if yes, what parts)? _____
- f _____ weapon cause any parts of your body to become sore (if yes, how and what parts)? _____

8. While carrying the test weapon today did you find it difficult to:

(answer each)

yes - no

- | | |
|---------------------------------|----------------------------------|
| a _____ stoop | i _____ move on all fours |
| b _____ squat | j _____ climb |
| c _____ jump | k _____ swing |
| d _____ turn torso to the left | l _____ balance yourself |
| e _____ turn torso to the right | m _____ throw grenade |
| f _____ crawl | n _____ lie down |
| g _____ walk | o _____ stand up from lying down |
| h _____ run | p _____ chamber a round in M-16 |

- q ___ aim the M-16 rifle
r ___ fire the M-16 rifle
s ___ reload the M-16 rifle

9. Was there any particular part of the test weapon not mentioned above that gave you trouble? Explain. _____

10. How would you change the test weapon to improve portability keeping in mind that you must carry it? _____

11. Was there anything about the test weapon that you particularly liked?

12. If the weight of the weapon you carried two days ago was rated 3 on a scale of 1 to 5 (5 is heaviest), how heavy would you rate the weapon you carried today in comparison to that one? (circle one of the following)

	a lot	a little	same	a little	a lot	
(LIGHTER)	1	2	3	4	5	(HEAVIER)

13. If the length of the weapon you carried two days ago was rated 3 on a scale of 1 to 5 (5 is longest), how long would you rate the weapon you carried today in comparison to that one? (circle one of the following)

(SHORTER)	a lot	a little	same	a little	a lot	(LONGER)
	1	2	3	4	5	

14. Which test weapon would you prefer to carry? (check one)

___ the weapon you carried today. ___ the weapon you carried two days ago.

APPENDIX E

ANALYSIS OF VARIATION FOR DUNNETT COMPARISON

TABLE 1E

Analysis of Variation for Dunnett Comparison

	H	E	I	L	C	
	5.43	4.31	6.40	3.67	4.39	
	5.11	5.70	4.31	5.99	4.56	
	4.16	4.29	4.60	4.72	5.10	
	4.16	4.20	5.50	4.60	4.71	
	5.88	5.60	4.98	4.18	5.20	
	7.42	4.68	3.53	4.05	4.70	
	5.00	5.03	4.68	4.14	4.98	
	5.50	4.09	5.56	5.56	5.27	
	5.44	5.17	5.77	5.48	4.73	
	4.56	6.21	5.65	5.61	6.09	
	4.70	5.04	4.25	6.18	3.79	
	4.19	5.03	4.49	5.50	5.25	
	4.73	4.95	4.70	4.25	5.44	
	4.40	4.14	3.90	3.98	3.62	
	7.41	5.14	6.20	5.02	5.72	
	6.58	5.58	5.43	6.20	5.25	
	5.94	6.22	5.52	4.20	4.85	
	4.80	6.72	4.51	5.26	5.18	
	8.90	5.32	5.81	5.82	5.05	
	7.02	5.22	5.70	5.78	5.85	
	6.51	7.39	8.08	5.79	5.02	
	6.08	6.34	5.53	5.23	5.29	
	6.27	6.18	6.47	4.99	5.99	
	6.91	6.32	6.05	6.34	4.37	
	4.09	4.65	4.94	3.89	4.25	
	5.32	4.50	4.34	4.45	4.30	
	4.21	4.75	4.58	4.50	4.64	
	4.35	5.67	4.41	4.60	4.48	
	5.74	5.40	5.35	6.16	4.42	
	7.87	5.23	3.59	4.72	4.56	
	4.56	4.78	4.85	4.43	4.56	
	5.76	5.38	5.21	5.11	5.40	
	5.10	4.85	5.41	6.59	5.13	
	4.57	5.64	6.61	4.40	5.32	
	4.59	4.08	4.45	5.48	3.76	
	4.66	4.44	4.10	4.96	4.08	
	4.76	4.64	4.41	3.84	4.75	
	4.48	4.05	3.98	3.89	3.62	
	6.06	6.17	6.18	5.20	5.06	
	6.61	5.57	5.12	5.80	5.27	
	7.74	6.48	5.40	4.99	4.61	
	5.28	5.26	5.10	5.50	5.20	
	5.05	6.18	5.12	5.61	4.90	
	6.80	5.17	4.80	5.58	5.84	
	6.55	7.35	7.44	6.92	5.50	
	5.80	6.00	6.17	5.64	5.00	
	6.73	6.48	6.20	5.38	6.40	
	6.70	5.99	6.48	6.01	4.36	
Tj	270.42	257.57	251.85	246.28	235.80	
(Xj ²)	1587.28	1416.01	1364.45	1294.69	1177.07	
Tj	5.633	5.366	5.247	5.130	4.912	
(1) G ²	= 6635.60	(2)	(X ²) = 6839.53	(3)	(Tj) ² = 6649.02	
	12n			n		

Source of Variation	SS	df	MS	F
Systems	13.42	4	3.355	4.138*
Experimental error	190.51	235	.810	
TOTAL	203.93	239		

* The overall F exceeds the critical value at the .05 level.

G=126196

TABLE 2E

Using the Method of Dunnett^a and comparing each load with LAW(C)

$$t_{L,C} = \frac{5.130 - 4.912}{\left[\frac{2(.810)}{48} \right]^{1/2}} = \frac{.218}{.183} = 1.187$$

Similarly for System I,

$$t_{I,C} = \frac{.335}{.183} = 1.825$$

and for System E,

$$t_{E,C} = \frac{.454}{.183} = 2.480$$

and

$$t_{H,C} = \frac{.721}{.183} = 3.940$$

From Dunnett's table, values larger than 2.16 are significantly greater than the control. Therefore, E and H are significantly greater than the control but systems L and I are not.

^aWiner, B. J. Statistical principles in experimental design. New York: McGraw-Hill (Series in Psychology), 1962.

APPENDIX F

**PERCENT CHANGE IN COURSE TIME (LBE = 0)
VERSUS LOAD WEIGHT**

APPENDIX F

% Change in Course Time (LBE = 0)

vs.

Load Weight (lbs)

25" $Y = 19.68 \exp (.0446X) - 20$

	Wt.	0	5	8	16	24
Observed	Y	0	4.25	8	21	37
Computed	Y	-.32	4.60	8.12	20.18	37.40

31" $Y = 20.40 \exp (.0459X) - 20$

	Wt.	0	5	8	16	24
Observed	Y	0	-	10	23.5	40
Computed	Y	.40	5.66	9.44	22.49	41.32

37" $Y = 20.84 \exp (.0476X) - 20$

	Wt.	0	5	8	16	24
Observed	Y	0	-	12	26	43
Computed	Y	.84	6.45	10.50	24.63	45.31

43" $Y = 21.27 \exp (.0492X) - 20$

	Wt.	0	5	8	16	24
Observed	Y	0	-	14	28.5	46
Computed	Y	1.27	7.21	11.54	26.76	49.33

APPENDIX G

PERCENT OF MEN NOT ABLE TO KEEP UP WITH SLOWEST MAN AT FIGHTING LOAD

TABLE 1G

% of Men Not Able to Keep Up With
Slowest Man at Fighting Load (37 lbs)
Not Carrying Antitank Weapon

Weapon	Not Able	Able	%
LAW	3	21	12.5
25" & 31" 8 lb	7	17	29.2*
43" 8 lb	8	16	33.3
37" 8 lb & 25" 16 lb	11	13	45.8
37" 16 lb	13	11	54.2
37" 24 lb	17	7	70.8
25" (3 ea.)	20	4	83.3
25" 24 lb	19	5	79.2
43" 24 lb	22	2	91.7
31" (3 ea.)	23	1	95.8

*Chi square significant < .05

APPENDIX H

AIM CALCULATIONS FOR DIFFERENT LOADS

TABLE 1H
AIM CALCULATIONS FOR LOAD A

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1	1.273	9.214
2	2.846	2.272
3	1.412	7.090
4		
5	2.701	1.933
6		
7	1.693	1.471
8		
9	2.395	0.584
10		
11		
12		
13	1.176	1.846
14		
15	4.219*	1.659
16	3.016	2.756
17	0.962	10.996*
19	1.776	2.229
20	2.419	3.198
21	1.376	1.514
22		
23	2.003	2.332
24	2.612	3.667
MEAN	2.125	3.517
STDDEV.	0.878	3.070
ADJUSTED MEAN	2.103	2.590

*Data omitted

TABLE 2H
AIM CALCULATIONS FOR LOAD B

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1		
2	1.634	4.904*
3		
4	0.858	2.679
5		
6	1.587	1.280
7	1.207	4.177
8		
9		
10	1.156	1.167
11		
12		
13	1.375	1.618
14	2.249	2.109
15	4.405	1.553
16		
17	1.979	1.937
19		
20	19.959*	2.107
21		
22	10.124	2.266
23	1.778	2.003
24	1.112	1.999
MEAN	3.802	2.292
STDDEV.	5.449	1.087
ADJUSTED MEAN	2.490	2.812

*Data omitted

TABLE 3H
THE MAN-WEAPON AIM CALCULATIONS FOR LOAD C

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1	2.042	1.771
2	0.926	11.131*
3		
4	1.652	4.612
5	4.668	5.308
6	1.181	1.013
7	1.814	1.540
8	1.796	0.425
9	8.731*	6.083
10	1.457	2.523
11		
12		
13	3.190	0.659
14	0.682	3.335
15	1.504	3.399
16		
17	1.925	1.757
19	1.858	1.856
20	3.882	1.740
21	4.395	1.736
22	2.540	2.805
23	0.905	1.327
24	0.841	1.350
MEAN	2.421	2.862
STDDEV.	1.928	2.527
ADJUSTED MEAN	2.21	2.565

*Data omitted

TABLE 4H
THE MAN-WEAPON AIM CALCULATIONS FOR LOAD D

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1	2.323	3.208
2	1.805	1.722
3		
4	14.914*	2.049
5	3.442	3.182
6		
7	1.460	1.866
8		
9	1.618	1.209
10	1.949	4.865
11	0.970	1.865
12		
13		
14	3.037	4.983*
15	2.394	1.588
16	3.106	2.678
17	2.021	2.865
19	3.204	2.547
20		
21		
22	2.180	2.080
23	0.793	1.571
24		
MEAN	3.014	2.552
STDDEV.	3.385	1.133
ADJUSTED MEAN	2.426	2.260

*Data omitted

TABLE 5H

THE MAN-WEAPON AIM CALCULATIONS FOR LOAD F

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1	2.632	2.748
2	0.890	11.185*
3	1.839	5.330
4	0.848	1.722
5	3.342	1.897
6	1.111	4.870
7	0.640	2.270
8	1.024	2.011
9		
10		
11		
12		
13	3.141	2.509
14		
15	3.078	1.962
16	1.831	2.715
17	1.943	1.901
19	1.913	1.042
20		
21	1.243	1.598
22	13.289*	1.855
23	1.270	2.584
24		
MEAN	2.502	3.012
STDDEV.	3.004	2.452
ADJUSTED MEAN	2.043	2.690

*Data omitted

TABLE 6H
THE MAN-WEAPON AIM CALCULATIONS FOR LOAD E

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1	1.214	1.571
2	2.619	5.744
3	1.596	0.524
4	2.883	1.935
5	2.249	1.447
6	1.683	1.862
7		
8	2.232	2.184
9	3.954*	5.219
10	1.329	2.537
11		
12	2.858	4.049
13	1.442	2.004
14	2.623	3.619
15	3.152	8.500
16	2.417	1.737
17	2.278	1.513
19	1.474	1.700
20	2.114	15.995*
21	1.575	1.101
22		
23		
24	1.660	4.181
MEAN	2.176	3.548
STDDEV.	0.724	3.595
ADJUSTED MEAN	2.074	2.509

*Data omitted

TABLE 7H
THE MAN-WEAPON AIM CALCULATIONS FOR LOAD H

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1	1.677	2.350
2	19.265*	1.830
3	0.539	2.173
4	0.962	2.376
5	3.816	2.038
6		
7	7.366*	1.081
8	1.197	2.089
9	1.854	3.190
10	2.575	1.519
11	1.119	0.731
12		
13	3.521	4.170
14		
15		
16	1.959	4.551
17	2.158	3.770
19		
20	2.806	1.873
21		
22	2.671	3.530
23	1.359	2.558
24	1.553	1.425
MEAN	2.788	2.427
STDDEV.	2.487	1.080
ADJUSTED MEAN	2.062	2.471

*Data omitted

TABLE 8H

THE MAN-WEAPON AIM CALCULATIONS FOR LOAD G

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1	1.397	1.610
2		
3	0.402	1.184
4		
5	2.322	3.342
6		
7	1.080	0.768
8	1.920	1.340
9	2.271	6.518*
10	4.835	1.060
11	1.424	0.918
12	4.332	1.335
13		
14	1.687	1.056
15	4.219	0.839
16	4.706	2.430
17		
19	1.153	2.577
20	1.484	1.331
21	5.624	2.615
22	5.165	6.749*
23	0.613	4.166
24	1.601	2.175
MEAN	2.569	2.334
STDDEV.	1.723	1.820
ADJUSTED MEAN	2.568	2.101

*Data omitted

TABLE 9H

THE MAN-WEAPON AIM CALCULATIONS FOR LOAD J

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1		
2		
3	1.105	1.570
4	1.385	3.290
5	4.489	1.088
6	3.152	3.073
7	0.935	1.407
8		
9	0.771	2.280
10	1.909	1.584
11		
12	2.929	2.530
13	1.955	1.053
14	1.129	1.175
15	4.039	1.532
16	1.311	0.958
17	2.982	1.203
19		
20	2.072	6.127*
21		
22	9.818*	1.004
23	2.453	4.635
24	2.172	2.120
MEAN	2.624	2.155
STDDEV.	2.140	1.432
ADJUSTED MEAN	2.487	2.552

*Data omitted

TABLE 10H

THE MAN-WEAPON AIM CALCULATIONS FOR LOAD I

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1	1.440	2.077
2	1.239	2.028
3	4.769	2.215
4	1.208	2.886
5	2.786	4.264
6	1.981	2.724
7		
8	2.936	2.727
9	2.110	2.979
10		
11		
12		
13	0.818	8.122*
14	1.231	1.081
15	3.654	2.844
16	2.122	1.787
17		
19	1.508	1.674
20	3.207	1.141
21	1.907	1.374
22	2.320	2.946
23	14.260*	6.066
24		
MEAN	2.912	2.878
STDDEV.	3.096	1.813
ADJUSTED MEAN	2.072	2.410

*Data omitted

TABLE 11H
THE MAN-WEAPON AIM CALCULATIONS FOR LOAD K

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1	1.855	0.445
2	1.363	0.600
3		
4	1.245	2.456
5		
6	2.166	2.196
7	3.196	2.026
8	2.412	2.734
9	1.934	2.245
10		
11	1.053	1.750
12		
13	1.651	2.644
14	2.638	1.135
15	2.253	1.744
16	2.094	1.879
17	2.389	3.571
19	1.013	1.509
20	2.088	1.657
21		
22	2.178	0.785
23	0.823	1.050
24	5.746*	3.057
MEAN	2.116	1.860
STDDEV.	1.097	0.857
ADJUSTED MEAN	1.852	2.134

*Data omitted

TABLE 12H
THE MAN-WEAPON AIM CALCULATIONS FOR DAY R

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1	4.428	1.657
2	4.472	11.145*
3	3.556	2.967
4	2.981	1.216
5	1.519	2.175
6	2.394	1.513
7	2.110	5.943
8	1.508	2.832
9	1.159	1.009
10	2.552	1.455
11	3.605	1.075
12	2.377	1.011
13	3.849	1.952
14	1.616	3.921
15	1.468	2.491
16	0.705	3.542
17	1.050	3.945
19	1.820	1.800
20	2.856	1.225
21	3.487	3.361
22	3.269	2.500
23	2.126	2.620
24	2.682	3.342
MEAN	2.504	2.813
STDDEV.	1.074	2.182
ADJUSTED MEAN	2.253	2.409

*Data omitted

TABLE 13H
THE MAN-WEAPON AIM CALCULATIONS FOR DAY R2

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1	1.253	2.669
2	3.911	1.724
3	1.384	1.305
4	1.651	1.783
5	6.314	4.567
6	6.897	2.089
7	1.569	0.959
8	1.469	1.404
9		
10	1.292	3.143
11	3.283	1.353
12	3.395	6.064*
13	3.553	1.717
14	1.725	1.623
15	2.292	3.176
16	2.625	2.248
17	1.453	4.682
19	1.705	2.191
20	1.664	2.020
21	3.119	2.015
22	5.072	3.116
23	8.694*	4.627
24		
MEAN	3.063	2.570
STDDEV.	2.086	1.362
ADJUSTED MEAN	2.717	2.447

*Data omitted

TABLE 14H
THE MAN-WEAPON AIM CALCULATIONS FOR DAY R3

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1	0.698	3.355
2		
3	0.824	1.629
4	1.139	0.786
5	5.904	2.718
6	0.507	0.705
7		
8	2.834	1.952
9	12.711*	3.962
10	1.564	2.258
11	1.138	1.518
12	1.255	0.884
13	2.131	0.983
14	2.051	2.195
15		
16	1.571	2.888
17	2.575	1.489
19	2.432	1.405
20	1.445	1.244
21		
22		
23	1.116	6.032*
24	2.664	3.470
MEAN	2.475	2.193
STDDEV.	2.832	1.368
ADJUSTED MEAN	1.910	2.318

*Data omitted

TABLE 15H

THE MAN-WEAPON AIM CALCULATIONS FOR LOAD L

SUBJ.	STDDEV RAD BEFORE	STDDEV RAD AFTER
1	1.666	1.441
2	3.119	3.422
3	1.056	0.915
4	1.494	2.894
5		
6	1.948	1.046
7	4.281	0.850
8	1.572	2.846
9		
10	1.177	0.815
11		
12	1.785	6.509*
13		
14	1.711	2.482
15		
16		
17	1.017	3.577
19	1.259	2.368
20	1.739	1.430
21		
22	3.154	1.433
23		
24	4.510*	6.182
MEAN	2.099	2.547
STDDEV.	1.126	1.802
ADJUSTED MEAN	1.948	2.399

*Data omitted

APPENDIX I

M14 AIMING DATA FILM

TABLE 1I
M14 Aiming Data Film

Subjects	Conditions											
	<u>A</u> BA	<u>B</u> BA	<u>C</u> BA	<u>D</u> BA	<u>E</u> BA	<u>F</u> BA	<u>G</u> BA	<u>H</u> BA	<u>I</u> BA	<u>J</u> BA	<u>K</u> BA	<u>L</u> BA
1		x						x	x			x
2			x	x	x						x	
3	x					x x					x	
4						x		x x	x	x		
5	x					x		x		xx		
6		x							x			x x
7	x	x										
8					x		x					
9			x	x	xx		x					
10		x					xx					x
11									x x			
12	x	xx	x							x	x	x
13	x x	x							x	xx		
14		x		x								
15	x		x	x	x							
16	x			x						x	x	
17				x		x		x			x	
18		x					x	x		x		
19						x	x				x	
20					x		x	xx				
21			x						x			
22			x						xx	x		x
23		x				x x		x			x	
24	x		xx									x

APPENDIX J

MEANS AND STANDARD DEVIATIONS FOR

THE BIPOLAR ADJECTIVE RATINGS

Weapon	1		2a		2b		2c		2d	
	Ease of Carry		Compact		Light		Short		Comfortable	
	\bar{x}	σ	\bar{x}	σ	\bar{x}	σ	\bar{x}	σ	\bar{x}	σ
C (LAW) 5 lb	1.19-	.39	1.43-	.92	1.83-1.37		1.36-	.77	1.83-1.05	
L 25" 8 lb	1.59-	.58	1.83-	.70	1.62-	.69	2.00-	.98	2.52-1.06	
K 25"16 lb	3.39-1.24		2.91-1.21		3.96-1.12		1.96-	.62	3.78-1.25	
J 25"24 lb	4.29-1.03		2.71-1.83		4.45-1.20		1.55-	.84	4.41-	.94
A 25" 8 lb										
3 ea	4.65-	.79	4.52-	.91	4.67-	.56	3.10-1.19		4.38-1.21	
I 31" 8 lb	2.14-	.62	2.52-	.96	2.00-	.85	2.64-	.93	3.00-1.17	
B 31" 8 lb										
3 ea	4.32-	.97	4.35-1.00		3.91-1.25		3.22-1.02		4.54-	.82
H 37" 8 lb	2.33-1.04		3.27-1.42		2.05-1.15		3.73-1.29		3.27-1.21	
G 37"16 lb	3.77-1.13		3.91-1.04		3.43-1.14		4.13-	.90	3.78-1.14	
F 37"24 lb	4.50-	.74	4.52-	.71	4.48-	.77	4.09-1.02		4.45-	.89
E 43" 8 lb	3.05-1.17		3.81-1.11		2.14-	.42	4.50-	.89	3.82-1.03	
D 43"24 lb	4.80-	.51	4.77-	.85	4.77-	.85	4.55-1.02		4.59-1.15	

2e		2f		2g		2h		2i		2j	
Stable		Small		Clings		Tight		Manage- able		Effort- less	
\bar{x}	σ	\bar{x}	σ	\bar{x}	σ	\bar{x}	σ	\bar{x}	σ	\bar{x}	σ
2.26-1.29		1.70-1.04		3.09-1.14		2.83-1.20		1.87-1.29		2.70-1.30	
2.87-1.39		1.94- .78		3.43-1.01		3.30-1.12		2.57- .97		2.87-1.08	
3.91-1.06		2.70-1.16		3.57-1.21		3.57-1.10		3.43-1.17		3.43- .97	
3.91-1.24		2.14-1.14		4.24- .92		3.64-1.37		4.09-1.24		3.45-1.30	
4.86- .35		3.65-1.31		3.74-1.62		4.63- .58		4.35-1.11		3.95-1.32	
3.45-1.27		2.73- .81		3.64- .99		3.68-1.06		3.09-1.20		2.71-1.03	
4.64-1.11		3.48-1.21		3.36-1.67		4.14-1.32		4.13-1.23		3.52-1.31	
3.36-1.30		3.27-1.32		3.13- .90		3.23-1.24		2.82-1.15		3.18- .72	
4.13- .90		3.22-1.25		3.65-1.27		3.59-1.03		3.74- .99		3.52-1.06	
4.36- .98		4.13-1.03		3.86-1.29		4.09-1.10		4.26-1.15		3.57-1.50	
3.78-1.02		4.18- .83		3.32-1.22		3.50-1.12		3.45-1.27		3.32-1.22	
4.73- .54		4.59- .84		3.95-1.33		3.95-1.22		4.45-1.08		4.14-1.36	

APPENDIX K

MEAN RATINGS FOR THE DIFFERENT SYSTEMS

TABLE 1K

1. Ease of Carry

Weapon	LAW	L(25"81b)	I(31"81b)	H(37"81b)
\bar{X}/σ	1.19/.39	1.59/.58	2.14/.62	2.33/1.04
T	----	2.804	6.354	5.028
Level of significance	---	.005	.005	.005

2b Light

Weapon	LAW	E(43"81b)	G(37"161b)
\bar{X}/σ	1.83/1.37	2.14/.42	3.43/1.14
T	---	1.060	4.398
Level of significance	---	.200	.005

2c Short

Weapon	LAW	L(25"81b)	I(31"81b)
\bar{X}/σ	1.36/.77	2.00/.98	2.64/.93
T	---	2.516	5.194
Level of significance	---	.010	.005

2d Comfortable

Weapon	LAW	L(25"81b)	I(31"81b)	H(37"81b)
\bar{X}/σ	1.83/1.05	2.52/1.06	3.00/1.17	3.27/1.21
T	---	2.266	3.646	4.403
Level of significance	---	.025	.005	.005

2e Stable

Weapon	LAW	L(25"81b)	I(31"81b)	H(37"81b)
\bar{X}/σ	2.26/1.29	2.87/1.39	3.45/1.27	3.36/1.30
T	---	1.576	3.220	2.942
Level of significance	---	.100	.005	.005

2i Manageable

Weapon	LAW	L(25"81b)	I(31"81b)	H(37"81b)
\bar{X}/σ	1.87/1.29	2.57/.97	3.09/1.20	2.82/1.15
T	---	2.125	3.392	2.693
Level of Significance	---	.025	.005	.005

TABLE 2K

7f. Weapon Cause Soreness

Weapon	LAW	L(25"8 lb)	I(31"81b)	H(37" 81b)
Yes/No	2/21	4/19	6/16	8/14
T	-	.77	2.66	4.50
Level of Significance	-	-	.250	.050

APPENDIX L

TABULATED RESPONSES BY THE SUBJECTS

3. Did any of the following characteristics about the weapon you carried today cause you difficulty?

4. Which obstacle in the portability course gave you the most difficulty because of having to carry the test weapon?

WEAPON	WEIGHT	LENGTH	POSITION OF CARRY	LOW CRAWL	HIGH CRAWL	5' WALL	TUNNEL	HURDLES
C	—	1	7	11	1	—	—	1
L	1	1	16	14	6	1	—	—
K	15	2	14	13	5	1	3	—
J	20	—	13	12	3	4	1	1
A	17	6	16	15	1	7	—	—
I	—	6	14	15	4	1	—	—
B	12	11	17	17	—	3	—	—
H	1	14	7	15	1	—	—	—
G	11	18	11	14	5	2	3	1
F	19	14	16	16	3	4	2	—
E	—	20	10	18	1	3	2	1
D	20	21	16	10	1	2	1	3
TOTAL	116	114	157	170	31	28	12	7

5. What was it about the test weapon that caused you to have the difficulty with the obstacle in question number 4?

WEAPON	NONE	SLIPS	LENGTH	WEIGHT	POSITION OF CARRY	HOOKS NECK	GOT STUCK	EVERYTHING
C	11	6	—	—	4	—	3	—
L	6	14	—	—	1	3	2	—
K	3	16	—	6	2	2	—	—
J	2	13	1	7	1	1	—	1
A	—	10	—	8	7	—	2	1
I	4	11	7	—	1	—	1	—
B	5	10	1	5	4	—	2	1
H	7	2	6	2	4	1	3	1
G	2	7	6	1	5	1	3	1
F	1	7	10	11	3	1	2	1
E	2	6	11	1	2	3	2	1
D	4	2	11	11	2	1	1	1
TOTAL	47	104	53	52	36	13	21	8

6. Which obstacle in the portability course gave you the least difficulty?

WEAPON	LOGS	ROPE SWING	CHANGE DIRECTION	ELEVATED ROOM	HIGH CRAWL	5' WALL	BRIDGE	FOX HOLE	GRENADE THROW	STOMACH ROLL
C	9	3	1	—	3	1	—	—	—	1
L	9	1	2	—	1	1	1	—	—	—
K	11	4	1	1	—	—	—	—	1	—
J	9	5	1	—	—	—	1	1	—	—
A	11	4	—	1	—	—	—	—	—	—
I	13	4	2	1	1	1	—	—	—	—
B	11	1	2	1	1	—	—	1	—	—
H	11	4	1	1	—	1	—	—	—	—
G	14	3	1	2	1	—	—	—	—	—
F	8	3	2	2	—	—	1	—	—	—
E	13	6	1	1	—	—	—	—	—	—
D	10	2	3	—	2	1	—	—	—	—
TOTAL	129	40	17	10	9	5	3	2	1	1

7. While carrying the test weapon today did the:

WEAPON	STRAP CUT SHOULDER	GET TANGLED	FALL OFF SHOULDER	FLOP AROUND BUMP BODY	PREVENT FREE MOVEMENT	WEAPON CAUSE SORENESS
C	0	14	43	26	13	9
L	17	45	57	52	22	17
K	57	52	55	78	17	43
J	77	32	86	77	41	73
A	75	65	70	90	75	75
I	23	55	64	64	18	27
B	73	61	61	71	39	70
H	36	36	45	57	23	36
G	38	52	78	83	46	61
F	74	75	74	78	73	78
E	30	48	52	61	35	35
D	86	55	55	73	59	59

8. While carrying the test weapon today did you find it difficult to:

WEAPON	STOOP	SQUAT	JUMP	TURN LEFT	TURN RIGHT	CRAWL	WALK	RUN	MOVE ON ALL FOURS
C	9	9	17	17	17	43	4	17	35
L	13	9	13	17	17	74	10	26	39
K	23	17	52	22	22	78	4	39	70
J	57	38	73	52	50	86	24	55	73
A	75	75	95	65	65	95	60	95	85
I	13	18	27	9	9	77	14	27	36
B	50	52	65	48	33	74	25	70	57
H	23	23	27	23	14	59	0	9	36
G	54	43	57	52	48	87	22	52	78
F	67	70	87	57	43	91	35	74	83
E	30	27	36	23	27	73	14	27	55
D	76	77	91	64	64	91	50	77	64

8. While carrying the test weapon today did you find it difficult to:

WEAPON	CLIMB	SWING	BALANCE	GRENADE THROW	LIE DOWN	STAND UP	CHAMBER ROUND	AIM M-16	FIRE M-16	RELOAD M-16
C	10	10	10	5	10	13	5	4	4	4
L	5	10	5	5	17	22	0	4	0	0
K	35	22	17	17	35	38	5	4	4	4
J	45	36	45	18	45	70	14	14	14	14
A	80	68	60	55	55	71	48	35	40	35
I	23	14	0	9	9	22	0	0	0	5
B	52	39	43	26	26	62	22	18	17	17
H	14	9	0	9	5	17	0	0	0	0
G	52	33	30	27	35	52	21	17	17	17
F	67	57	48	31	57	70	17	22	13	13
E	30	17	14	26	45	36	10	5	5	5
D	77	57	45	50	64	73	36	32	29	29

9.

Was there any particular part of the test weapon not mentioned above that gave you trouble? Explain.

10.

How would you change the test weapon to improve portability keeping in mind that you must carry it?

WEAPON	NO	LENGTH	WEIGHT	STRAPS	EVERYTHING	NO	LENGTH	WEIGHT	STRAPS	EVERYTHING
A	15	—	—	5	1	2	—	7	7	3
B	16	—	—	4	1	3	2	5	10	4
C	22	—	—	1	—	12	—	—	10	—
D	21	—	2	2	2	2	14	15	5	2
E	18	1	—	1	—	3	16	1	5	—
F	19	—	1	3	1	2	4	15	9	4
G	22	—	—	—	—	3	11	9	9	1
H	21	1	—	1	—	2	9	1	8	2
I	20	—	1	—	—	4	5	1	8	—
J	17	—	1	3	1	2	—	16	6	2
K	19	—	3	1	—	4	—	10	8	—
L	22	—	—	—	1	6	1	—	13	—
TOTAL	232	2	8	21	7	45	62	80	98	18

11. Was there anything about the test weapon
that you particularly liked?

WEAPON	NO	LENGTH	WEIGHT
A	17	1	1
B	22	0	1
C	5	7	13
D	22	0	—
E	12	1	9
F	22	2	—
G	21	1	1
H	15	1	9
I	14	2	8
J	16	8	—
K	12	10	2
L	10	11	9
TOTAL	188	44	53

Easiest - Hardest

Condition	Code	\bar{X}	σ
LAW (25/5)	C	1.00	0
25/8	L	2.33	.99
25/16	K	6.00	1.50
25/24	J	9.50	1.63
31/8	I	3.79	1.04
37/8	H	3.92	.76
37/16	G	6.83	1.70
37/24	F	8.42	1.11
43/8	E	5.17	1.49
43/24	D	10.17	1.62

	12. Lighter		13. Shorter		14. Today's Weapon
Weapon	\bar{X}	σ	\bar{X}	σ	%
LAW(25/5)	1.43	.85	1.95	1.00	95
L 25/8	1.57	.79	2.14	1.08	100
K25/16	3.33	1.39	2.19	.91	41
J25/24	3.80	1.33	1.65	.73	50
I31/8	1.95	1.32	2.55	1.07	86
H37/8	2.35	1.39	3.35	1.35	65
G37/16	2.76	1.23	3.29	1.16	43
F37/24	3.90	1.19	3.76	1.31	29
E43/8	2.20	1.20	4.00	1.00	80
D43/24	4.20	1.21	4.40	1.02	19
A25/8(3)	4.40	1.17	2.89	1.37	32
B25/8(3)	3.57	1.43	3.24	.97	15

Absolutely Would Not Want To Carry

Condition	Code	%
LAW(25/5)	C	0
25/8	L	0
25/16	K	8
25/24	J	67
31/8	I	0
37/8	H	13
37/16	G	21
37/24	F	58
43/8	E	13
43/24	D	96

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13. ABSTRACT

A field study was conducted to determine the effect of weight and length of an antitank system on the performance of an infantryman. A portability test course was designed and constructed. The ability of soldiers from the 82d Airborne Division to negotiate the course was measured and the soldiers' ratings of each of the systems they carried were obtained. Functional relationships between weight, length and performance were obtained with an indication of the effects of volume, i.e., multiple carry. The test soldiers were able to discriminate among the loads using the bipolar adjective rating technique, and for what appears to be a reluctance-to-carry factor, tended to rate the loads carried in a manner which parallels the performance findings. The infantryman's performance degrades and he is reluctant to carry 81mm antitank systems longer than 31 inches (at eight pounds) and heavier than eight pounds when added to his current fighting load.

14.	KEY WORDS	LINK A		LINK B		LINK C	
		ROLE	WT	ROLE	WT	ROLE	WT
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